Public Works (1897) Department.

G.O., No. 2302 25

DATED 21st August 1897

[Despatch Abstract.]

Water Supply Scheme Bellary. Proc: Lt-n Deft passing orders on the subject of a — Compd & S.E. 66 Circle.

J.C. 21/8

[P.W. 25. 5,000—30-11-96.]

Indexed. ✓

BACK PAPERS.

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Public works (1897) department

Current Number: 8048

Government (1897) of Madras.

LOCAL AND MUNICIPAL.

No. 1121 W dy 22-4-93
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Recd. 13. 8. } 1897.
Regd. 13. 8.

Enclosures

Spare copies 8.

G.O., No. 1463 M., 21st June 1897.

No 2302 W dy 21.8.97
Communicated to the S.S. III cmtee.
16/8/97

JUNE.

S.S. III cmtee with 3 enclosures
R 23/8/97

T Tho
B. Tks

Bellary Water-supply Scheme.

Considering that the Alipore tank and the Copper Hills schemes for the water-supply of Bellary must be abandoned owing to the uncertainty of the water-supply and that the Hagari scheme which the Government is prepared to approve is beyond the means of the municipal council, and informing the municipal council with regret that, as matters stand at present in regard to Provincial finances, the Government cannot promise any grant from Provincial funds towards the last-mentioned scheme within any definite period.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

Read—again the following papers :—

G.O., Mis. No. 93 M., dated 23rd January 1893.

Abstract.—Referring to the Municipal Council, Bellary, with remarks, memorandum of the Chief Engineer, Public Works Department, regarding the water-supply scheme of Bellary.

G.O., Mis. No. 483 M., dated 10th April 1893.

Abstract.—Stating that the Bellary water-supply scheme may be considered as finally abandoned.

GO., Mis. No. 1469 M., dated 9th September 1895.

Abstract.—Sanctioning the allotment of Rs. 2,000 required by the Bellary Municipal Council for the investigation of the Copper Mountain water-supply scheme.

G.O., Mis. No. 1936 M., dated 22nd November 1895.

Read—the following letter from the Secretary to the Government of India, Military Department, to the Secretary to the Government of Madras, Local and Municipal Department, dated Simla, 2nd November 1895, No. 2837 M.W. (Cantonments—Water-supply) :—

I am directed to forward, for the information of His Excellency the Governor in Council, a copy of the letter marginally noted from the Director-General of Military Works, relative to the provision of a pipe-water supply for the city and cantonment of Bellary and to observe that the question of the water-supply for this station has been for a very long time under consideration. I am therefore to request that, under His Excellency's orders, the local authorities may be urged to take steps towards securing an early settlement of the question.

No. 2891 B., dated the 4th October 1895, and enclosure.

Enclosures.

Copy of a letter from the Director-General of Military Works, to the Secretary to the Government of India, Military Department, dated 4th October 1895, No. 2891 B.

With reference to Military Department letter, No. 1593 M.W., dated 25th May 1893, I have the honour to forward herewith a copy of a preliminary report and rough approximate estimate amounting to 7½ lakhs, prepared by the Sanitary Engineer to the Madras Government, on a scheme for supplying the city and cantonment of Bellary with water from the Hagari river, distant about 8 miles from cantonments.

The Sanitary Engineer has also prepared a rough scheme for a supply from wells sunk in the sloping ground at the foot of the Copper Mountain, the cost being estimated at 5 lakhs.

I do not forward a copy of this last-named scheme, because it is acknowledged that the available data are too meagre to allow of a correct forecast being made of the quantity and quality of water that can be obtained from this source. The municipality have, however, allotted a sum of Rs. 2,000 with a view to a further investigation of this Copper Mountain scheme.

So far as my information goes, the most promising source of supply for the city and cantonment is the Hagari river, and from paragraph 3 of the Sanitary Engineer's report it will be seen that little doubt is entertained locally as to the sufficiency of its yield of water.

2. Turning now to the proposals put forward in the Sanitary Engineer's report, I observe that he recommends a provision of 15 gallons per head per diem for a combined civil and military population of 66,000 souls. The scale of 15 gallons all round appears to me excessive. Taking our experience in other cantonments as a guide, the total quantity of water required for the military population would be 65,000 gallons per day, made up as follows :—

1,039 Europeans	at 15 gallons per day	...	15,585
5,227 Natives	at 8 „ „	...	41,816
741 houses	at 10 „ „	...	7,410
		Total ...	64,811
		(Say)	65,000 gallons.

In this connection, I may mention that at Peshawar and elsewhere it has been found by practical test that 5 gallons per head per diem amply suffices to meet the wants of a native family.

3. In paragraphs 13 and 14 of his report the Sanitary Engineer calculates on a contribution of one lakh of rupees from the Military Works Department towards the initial cost of the scheme, and 3 lakhs from the Local Government. The total working charges (exclusive of interest) are estimated at Rs. 48,000 per annum.

Further, in paragraph 17, it is asserted that the inclusion of the barracks and Native Infantry lines in the scheme entails the whole of the town supply being lifted 30 feet higher than the requirements of the town demand. The charge for this additional lift is worked out to be Rs. 5,000 annually, which amount the Sanitary Engineer considers should be borne by the Military Department, exclusively. This would leave a balance of Rs. 43,000 for the annual pumping charges which it is proposed shall be shared by the Municipality and Military Department, in the proportion of the population, taking the military population at one-eleventh of the whole. Hence the proposed military share would be Rs. 5,000 for the additional lift *plus* $\frac{1}{11} \times$ Rs. 43,000 = Rs. 4,000, that is, a total of Rs. 9,000 per annum approximately.

To sum up: the Sanitary Engineer reckons on an initial contribution of one lakh of rupees from the Military Works Department, and 3 lakhs from the Local Government towards the capital cost, and a payment of Rs. 9,000 annually by the Military Department. It is hoped that the balance of the annual charges for pumping and interest will be covered by taxes, but on this point the Sanitary Engineer is not sanguine.

4. With regard to these proposals I fail to see any special reason for treating the Bellary scheme differently from those for Agra, Allahabad, &c. Consequently I do not recommend that any fixed annual sum be contributed towards the extra cost of the municipal headworks and mains due to the supply required for the cantonment. This extra cost should be covered by the price charged by the municipality for the water supplied to the cantonment.

The Military Department should only pay a certain rate per thousand gallons for water supplied as is done in the case of Agra, Delhi, Allahabad, and as has been proposed and accepted for Lebong.

Again, instead of an initial contribution of one lakh of rupees, the Military Works Department should provide or meet the cost of all reservoirs, distribution pipes, &c., required from beyond the point where the cantonment scheme will take off from the municipal main.

5. In paragraph 20 of his report, the Sanitary Engineer suggests that the municipality should levy a water-tax on private houses in the cantonment. This proposal is inadmissible as, whatever the powers of the municipality may be outside cantonment limits, that body have no authority to levy a water-tax within those limits, especially as the water supplied to the cantonment will be paid for at a certain fixed rate.

6. It is evident from the general tenor of the Sanitary Engineer's report that there exists some doubt whether the municipality of Bellary will be able to find the funds for their share of the work on the Hagari project, and it is, I am informed, mainly for this reason, that the investigation of the Copper Mountain source has been undertaken. Meanwhile, the Hagari scheme is in abeyance.

Should the Copper Mountain scheme prove to be practicable at a moderate cost, the municipality will doubtless be advised to accept it. If, on the other hand, the investigations show that sufficient water is not available at the base of the Copper Mountain, then the Hagari river project for water-supply to the cantonment and town should be worked out in detail without further delay.

In conclusion, I would suggest the expediency of pressure being brought to bear on the municipality through the Madras Government, with a view to an early settlement of the source of supply and the commencement of work on the one scheme or the other.

Report on the Bellary Water-Supply by the Sanitary Engineer to Government.

The Hagari Scheme.

The source of supply as proposed by Mr. Tremenheere is underflow in sandy bed of the Hagari river at a point close to the Hagari station on the Southern Mahratta Railway, which is, as the crow flies, about 8 miles from the Bellary Club. The scheme briefly is, to collect the underflow in Hagari in the best manner possible; to pump the water into service reservoir placed on the high ground on which the Bellary Club stands; and finally to distribute the water throughout the town and cantonment in the usual manner with pipes and fountains.

2. *Quality of water.*—The Hagari water has not been analysed. The popular opinion is that it is a good water; the villagers on the bank of the river drink its water. A fair idea of the quality of the Hagari water would be obtained by having the water of the railway well at Hagari analysed. This well is close to the margin of the river. I have made this suggestion to the Collector.

3. *Quantity of water.*—The Hagari is about 2,500 feet broad at the place it is proposed to tap it. It has a very deep sandy bed. The iron cylinders of the railway bridge are said to have been sunk 200 feet deep. From enquiries made of the villagers on the bank it appears that the dry weather level of water never falls more than 6 feet below the surface of the bed. A spring-channel that takes its rise a little above the village of Hagari is reported to have been flowing even during the famine of 1877. Taking these facts into consideration, there is little doubt about the sufficiency of water.

4. *Quantity of water required.*—The civil and military population is about 66,000. A provision of 15 gallons per head per diem should be made. The Collector considers that a provision of 10 gallons would be ample. This would no doubt be so for the first few years after the introduction of the scheme. But it is very likely that, within a period which will be very small compared with the life of the works, the consumption would exceed 10 gallons. As the pumping main will be about 8 miles in length, any future attempt to increase the supply from 10 to 15 gallons will involve a very considerable outlay. It will, therefore, be cheaper in the long run to make the delivery

main large enough to carry a supply calculated at 15 gallons per head. The pipe should therefore be capable of delivering $66{,}000 \times 15 = 990{,}000$ gallons per day of 24 hours = 687 gallons per minute.

5. *Pumping main.*—A 12-inch pipe with a hydraulic gradient of 2 in 1,000 will give the above supply. The weight per foot of 12-inch pipe to stand a head of 300 feet = 75 cwt. A mile of 12-inch piping at Rs. 150 per ton laid complete would cost Rs. 30,000.

6. *Lift.*—The bed of the Hagari is 215 feet below the ground near the Bellary Club, where it is proposed to construct the service reservoir. To this must be added 5 feet, level of water in reservoir above ground, and 15 feet, level of inlet to pumps below bed of the Hagari. The actual height to which water has to be lifted will be 235 feet.

7. Loss of head by friction through 8 miles of piping $8 \times 5{,}282 \times 2 = 85$ feet.

8. The total lift on the head against which pumps will have to work will be $235 + 85 = 320$ feet.

9. The consumption for some years to come will not exceed 10 gallons or $\frac{10}{15} \times 687$, say 460 gallons per minute. The head required to pass 450 gallons through a 12-inch pipe is 1·1 in 1,000, or say 50 feet in 8 miles of piping. The total lift in this case would be $235 + 45 = 280$ feet.

10. *Pumping power.*—For a supply of 10 gallons per head $\frac{460 \times 280 \times 10}{33{,}000} = 39$ pump horse-power, would be required, or 3 engines of 13 pump horse-power each; add one as a reserve engine; total required, 4 engines of 13 pump horse-power each.

11. *Estimate of works.*—The following is an approximate estimate of the scheme:—

	Rs.
Infiltration works	50,000
Engine house, Engine driver's quarters, store-shed land, &c. ...	50,000
Engines and pumps (4 of 13 P.H.P. each)	75,000
8 miles of 12″ C.I. pipes	2,40,000
Service reservoir	50,000
Distribution system	2,15,000
Total ...	6,80,000
Contingencies	70,000
Grand total ...	7,50,000

12. *Cost of pumping.*—Cost of pumping 10 gallons per head per diem for a population of 66,000 at 10 annas per million gallons lifted one foot high, would be $\frac{66{,}000 \times 10 \times 280 \times 365 \times 10}{1{,}000{,}000 \times 16}$ = say Rs. 43,000. To the above must be added Rs. 5,000, annual cost of establishment, repairs, &c., to the distributary system. The total working charges would be Rs. 48,000, exclusive of interest and sinking fund on the initial outlay.

13. *Allocation of charges.*—Calculating roughly, not more than a lakh of the initial cost of the scheme would fall on the Military.

14. The Government has helped several municipalities with a moiety of the cost of water-supply schemes. But in view of the large amount of the estimate and financial difficulties, it would be over-sanguine on the part of the municipality to expect a grant of more than 3 lakhs.

15. The municipality will therefore have to provide Rs. 3,50,000. Presuming that the whole of this amount would be borrowed from Government, it will involve an annual charge of Rs. 21,000.

16. If the barracks and native lines were excluded from the scheme, it would be possible to reduce the lift by about 30 feet, because Cowl Bazaar and Brucepet which constitute the whole of the municipality are lower than the general level of the cantonment.

17. The inclusion of the cantonment or rather the barracks and native lines in the scheme, compels the whole of the town supply being lifted 30 feet higher than the requirements of the town demand it. The cost of lifting the town supply 30 feet higher would therefore be a legitimate charge on the military. This charge works out to about Rs. 5,000 annually.

18. The balance of the pumping charges would be borne by the municipality and the military in the proportion of the population. The military share of the pumping charges would thus be Rs. $5,000 + \frac{6,000}{66,000} \times (\text{Rs. } 48,000 - 5,000) =$ say Rs. 9,000, and the municipality will have to bear Rs. $(48,000 - 9,000) = 39,000$.

19. The cost of the scheme to the municipality stands thus:—

	Rs.
Interest and sinking fund at 6 per cent. on Rs. 3,50,000	21,000
Pumping charges	39,000
Total ...	60,000

20. *Financial aspect.*—The amount collected as house tax at the maximum rate of $7\frac{1}{2}$ per cent. is about Rs. 28,000 yearly. This includes tax on private houses in the cantonment. An 8-per cent. water-tax which will be the maximum leviable when the new District Municipal Act is passed, would be about Rs. 30,000. This sum could be increased to some extent by the revision of taxes, but it seems doubtful if the municipality would be able to provide Rs. 58,000 annually even with its best efforts.

Order—Mis. No. 1936 M., dated 22nd November 1895.

Communicated to the Sanitary Engineer with the request that the investigation of the Copper Mountain scheme, for which an allotment of Rs. 2,000 was sanctioned in G.O., No. 1469 M., dated 9th September 1895, may be expedited and the result reported to Government at an early date.

(True Extract.)

(Signed) J. F. PRICE,
Chief Secretary.

To the Sanitary Engineer.

Copy to the Chairman, Municipal Council, Bellary,
through the Collector.

G.O., Mis. No. 1010 M., dated 15th June 1896.

Abstract.—Communicating to the Sanitary Engineer and the Municipal Council, Bellary, letter from the Government of India declining to consider the question of pipe-water supply for the town and cantonment of Bellary until a definite scheme has been laid before them.

Read—also the following papers:—

Report on the Bellary Water-Supply by the Assistant Sanitary Engineer to Government, dated 16th July 1896.

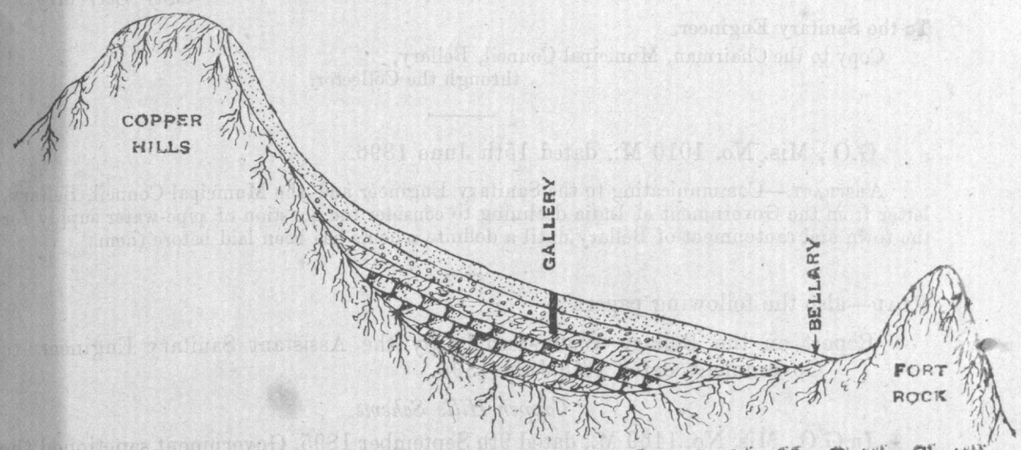
Copper Hills Scheme.

In G.O., Mis. No. 1469 M., dated 9th September 1895, Government sanctioned the execution of certain experiments in connection with the Copper Hills scheme. This report deals with the experiments made, and the proposals based on them.

2. I think it necessary to preface this report with a few general remarks in answer to doubts, that have been expressed in certain quarters, as to the possibility of finding any copious and permanent supply of water anywhere between Bellary and the Copper Hills. It has often been asserted that it is futile to look for water in any large quantities in rocky ground. This is a popular fallacy. Certainly, nobody would ever think of finding water in a compact mass of rock, such as the Bellary Fort Rock;

but it is a fact well known to every student of Geology and every practical observer, that rocks under certain conditions contain almost as much water as sand and loose gravel. Arenacious rocks, such as sand stones, conglomerate of lime nodules and lime stones, contain a large quantity of water, retained both by saturation and by storage in natural cracks and fissures. The section of the trial trench (*vide* paragraph 9) shows that the structure of the soil is of the above nature.

3. Bellary has always been regarded as a dry place. This is, quite naturally, the first impression of the new comer, as the cantonment stands high and dry; and even Cowl Bazaar and Brucepet, which form the bulk of the town, stand on ground with a sub-stratum of gneiss within a moderate depth of the surface, the outcrop of which is the Bellary Fort Rock. But old inhabitants of Brucepet and Cowl Bazaar say, their wells have never failed even in very bad years. When there is a cry of scarcity of water in Bellary, it does not imply that the wells in the town have run dry, but it implies that the Fort ditch and the Mainwarring tank—the principal sources of supply—have failed; for though the town wells have always been capable of yielding water, they are not used by the people owing to the unwholesomeness of water in them. In corroboration of the above facts, the following extract from Mr. J. W. Martin's (then Superintending Engineer, III Circle) letter No. 570, dated 17th May 1892, embodied in G.O., Mis. No. 1150 M., dated 2nd July 1892, may be cited: "I think I should mention that at present the wells in and around the town are all well supplied. I believe there is no record that they have ever been dry, and in my opinion, taking into consideration the formation of the country, it is most improbable they will ever become dry." It must be remembered that Mr. Martin wrote this in a hot season immediately succeeding a year the rainfall of which is the lowest on record in the past ten years. If even in such a dry year underground water was available in the town of Bellary, where the sub-stratum of compact rock is close to the surface, it follows that water must be available in greater abundance at some distance from the town in the direction of the Copper Hills, because midway between the Fort rock and the hills the gneissic bed lies a long way below the surface.



4. Coupled with the above, there is also the fact that in Mr. Puttia Chetti's well, which is on the line of the proposed gallery, the level of water has fluctuated within very small limits from season to season and from year to year. My informants were Mr. Puttia Chetti himself and his gardeners. Mr. Puttia Chetti's personal knowledge of the well is short, but the gardeners have known the well and the locality from their infancy. They say that the variation between the waterlevel in the dry and wet seasons in ordinary years is about a foot. Only in 1891—the year which gives the smallest record of rainfall in the past ten years—the level fell by 3 feet.

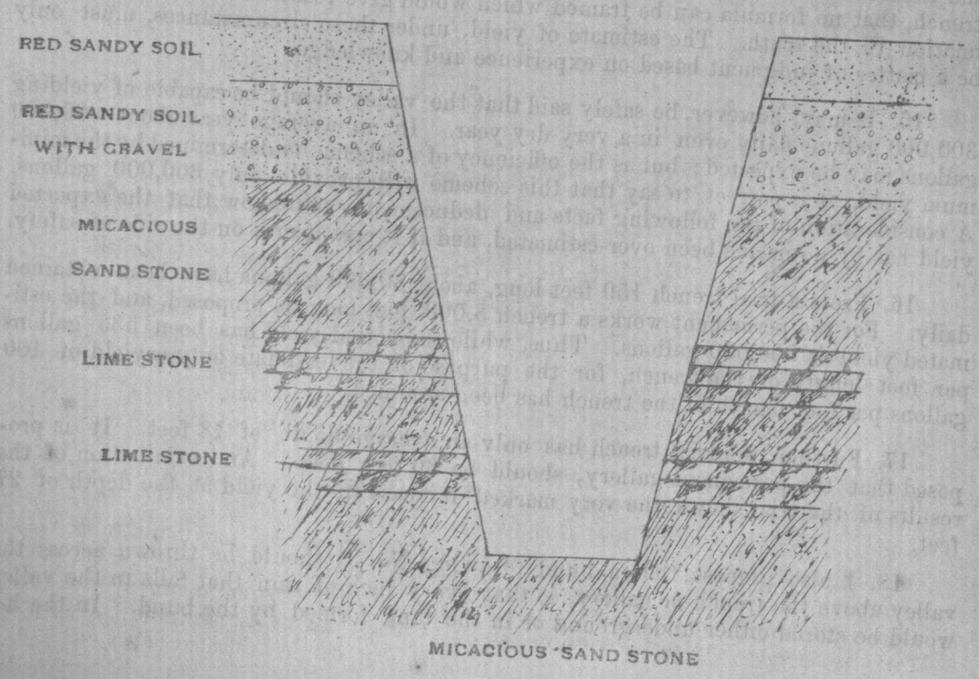
5. The facts and opinions here adduced go to prove the existence of underground water in the country immediately surrounding Bellary, and also that the water is more or less of a permanent character, and for all practical purposes independent of the season or the annual rainfall. The variation between the minimum and maximum annual rainfall at Bellary is so great, that it may be permitted to some to doubt the statement of permanency of waterlevel. But the fact is that the effect of one wet season on underground water does not disappear altogether for the next two seasons, and it seldom or never happens that two or three dry years succeed one another. Thus the natural storage of water underground, under the conditions prevailing at Bellary, is of the nature of a compensating reservoir, which tends to equalize the quantity and level of the underground water notwithstanding great differences in rainfall.

6. The water from the trial trench has been analysed. A copy of the analysis is attached. There is no reason to believe that the water contains any harmful impurities.

7. As the dry season is the proper time for the experiments, the work was not started until the 25th February 1896. The paucity of labour and the demand for coolies for picking cotton, this being the season for it, retarded the works very considerably. The usual resource under similar circumstances, *i.e.*, the importation of foreign labour, could not be adopted, work being of a small magnitude. It was necessary to close the works before the south-west monsoon was well advanced, and it was found impracticable to sink the whole trench to the full depth within the prescribed time. The results achieved are, however, quite sufficient for the purpose for which the experiment was made.

8. The work consists of a trench at right angles to the Billagalu vunka, at a point about a mile and a half from the municipal boundary of Bellary (drawing No. 1). The trench, as executed, is 150 feet long with an average bottom breadth of 12 feet. The 50 feet length, immediately next the river, is 14½ feet deep. The further 100 feet is 18 feet deep, and at the furthest end a pit is sunk reaching a depth of 27 feet (drawing No. 2).

9. The section of the trench, with reference to the structure of the soil, is at its deepest part somewhat as below :—



10. The results of the experiments summarised are as below :—

	Gls. per Minute.
Section A of trench 48′ × 14·1′ and 14½′ deep yielded	30
Section B of trench 83′ × 11·6′ and 18′ deep yielded	15
Section C of trench 11′ × 10′ and 27′ deep yielded	20
Total yield ...	65

11. Section A is nearer the stream and this accounts for its greater yield notwithstanding that its length is less than that of section B. On the other hand section C, which is furthest from the river, yielded in proportion to its length and area more than sections A or B, thus proving the efficacy of the deeper section in regard to the yield of water. This result goes to establish that in the permanent works, should they be constructed, the gallery or trench should be not less than 30 feet deep.

12. Judging by the lie of the various strata underground, the belief is tenable, that the deeper the trench the greater will be the yield of water until compact gneiss is reached. But it is problematical whether the extra cost, both initial and working, of a deeper gallery will be commensurate with the advantage of a greater supply. It will, therefore, be advisable to restrict the depth of the gallery to 30 feet, and make the supply dependent on a longer length rather than on an increased depth (drawing No. 3).

13. The valley to be tapped is about a mile in breadth to the foot of the hill. A gallery about 3,000 feet long is about the greatest length required to intercept practically the whole of the flow from the valley (drawing No. 3).

14. It is not possible to deduce, from the results of the experiments, a formula which will enable, with any pretence to accuracy, the computation of the yield from a longer length of trench or gallery. Calculations based on formulæ deduced from trials even in a homogeneous soil-like sand have led to most unsatisfactory results. In the present instance so much depends upon the porosity of the rock and the crevices and fissures in them, the nature and extent of which may vary with every foot of the trench, that no formula can be framed which would give results even with an approximation to the truth. The estimate of yield, under these circumstances, must only be a matter of judgment based on experience and knowledge.

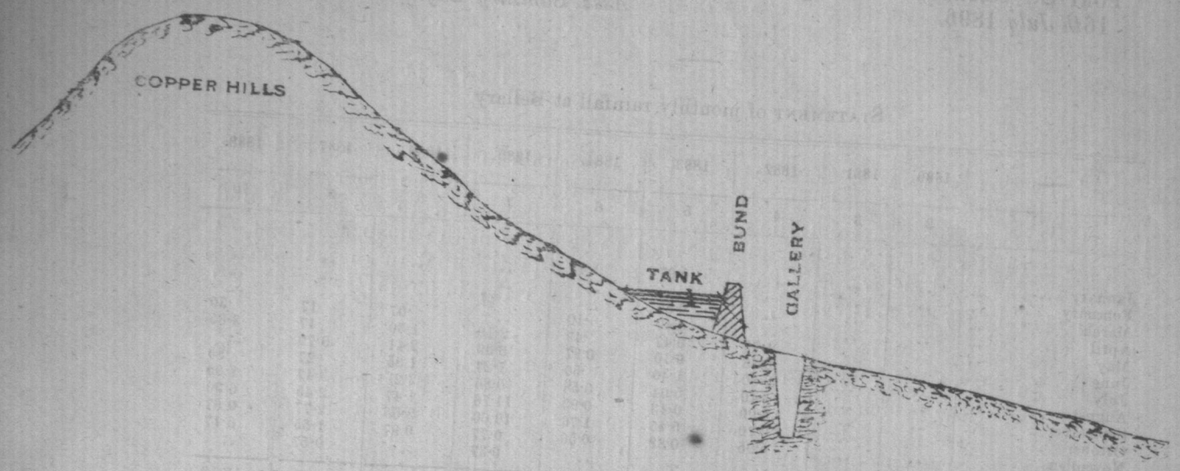
15. It may, however, be safely said that the valley should be capable of yielding 300,000 gallons daily even in a very dry year. In an average year about 600,000 gallons may be expected; but as the efficiency of a scheme is determined by the minimum yield, it is correct to say that this scheme will provide only 300,000 gallons. A consideration of the following facts and deducements will show that the expected yield has by no means been over-estimated, and if it errs it errs on the side of safety.

16. From a trial trench 150 feet long, about 80,000 gallons have been obtained daily. For the permanent works a trench 3,000 feet long is proposed, and the estimated yield is 300,000 gallons. Thus, while the actual yield has been 533 gallons per foot length of the trench, for the purpose of the estimate only a yield of 100 gallons per foot length of the trench has been assumed.

17. Further, the trial trench has only an average depth of 18 feet. It is proposed that the permanent gallery, should be 30 feet deep. An examination of the results of the trial shows the very marked increase in the yield at the depth of 27 feet.

18. I also propose that a bund (drawing No. 3) should be thrown across the valley above the trench or gallery, so that every inch of rain that falls in the valley would be stored either underground or in the tank formed by the bund. In the hot

weather, as the underground supply becomes diminished by pumping, it will be replenished by percolation from the tank. The top soil is gravelly and favourable for this purpose.



19. The area of the valley is about 9 square miles. The lowest rainfall within the past fifteen years was in 1884 when it was 7·34 inches. Of the water stored underground and in the tank, 50 per cent. would be available, the other 50 per cent. being allowed for loss by evaporation, &c., or say $3\frac{1}{2}$ inches would be available. $3\frac{1}{2}$ inches over an area of 9 square miles give 73 millions cubic feet. The town supply at 300,000 gallons per day amounts to less than 18 millions cubic feet per year.

20. It is well to state here, that the present year is far from being a typical dry year in Bellary. During the past five years the rainfall has been above the average, and last year the number of inches that fell stood at a figure, the highest but one in the past fifteen years (*vide* table of rainfall appended). Sufficient allowance has, however, been made for this in fixing the yield.

21. A supply of 300,000 gallons per diem will give only a little more than 5 gallons per head of the population. This supply is insufficient. The Sanitary Commissioner has suggested the combination of this supply with that of the Alipore tank. With the two schemes combined, the cantonment will get a supply of 15 gallons per head, and the town 10 gallons per head. The standard fixed for this Presidency is 15 gallons per head per diem. Though it should be the aim of every scheme to secure this quantity, circumstances do not often admit of it. With regard to Bellary it is well nigh a case of choice between half a loaf or starvation. Even with the prospects of a larger supply from the Hagari, the Collector of Bellary considered 10 gallons per head sufficient, or at any rate all that was possible.

22. The Copper Hills supply will cost, exclusive of distribution works:

		Rs.
Bund		35,000
Gallery		50,000
	Rs.	
Engine-house	10,000	
Drivers' quarters	4,000	
Store-shed	1,000	
Land and fencing	1,000	
Engines and pumps		16,000
Reservoir		20,000
Main pipes and valves		15,000
Laying and jointing		70,000
		14,000
Total ...		2,20,000

23. The best mode of combining the two supplies could be considered hereafter when working out the details of the scheme.

Fort St. George,
16*th July* 1896.

(Signed) HORMUSJI NOWROJI,
Asst. Sanitary Engineer to Government.

Statement of monthly rainfall at Bellary.

—	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
1	2	3	4	5	6	7	8	9	10
January	..	..	..	0·07	1·45	..	..	..	..
February	..	..	..	..	..	..	..	..	..
March	..	..	..	0·80	..	·17	..	..	..
April	..	..	..	0·40	·10	..	·07	·17	·30
May	..	..	1·75	0·47	·49	2·19	1·30	·47	3·85
June	..	..	0·38	0·10	0·97	3·39	2·41	6·79	..
July	..	..	0·80	1·40	·50	1·27	1 35	·27	·85
August	..	..	1·40	5·04	0·58	0·85	2·21	3·47	1·05
September	..	..	5·90	0·43	0·93	11·76	1·47	2·45	6·30
October	..	..	0·70	5·46	1·76	10·60	2·55	2·77	0·67
November	..	..	5·95	0·88	0·56	0·77	0 97	1·55	5·17
December	..	..	..	..	..	0·37	..	0·57	..
Total ..	..	..	16·88	15·05	7·34	31·37	12·33	18·51	18·19

—	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
	11	12	13	14	15	16	17	18
January	..	..	..	..	..	..	..	..
February	..	..	..	..	0·03	..	..	..
March	..	..	0·32	..	1·35	..	..	..
April	1·40	1·70	..	..	0·16	0·43	2·66	0·34
May	·93	1·42	2·39	0·46	0·56	3·66	2·91	6·03
June	·92	·75	2·23	5·40	3·08	0·81	2·31	0·83
July	1·86	1·05	0·52	1·12	4·97	1·09	1·94	..
August	1·20	0·97	1·37	6·45	4·04	3·74	1·83	..
September ..	11·63	6·20	0·30	3·46	1·28	1·40	7·80	..
October	8·90	6·16	1·00	5·54	6·40	6·58	7·79	..
November ..	0·60	5·50	0·65	0·25	1.26	2·09	2·09	..
December	..	..	..	..	..	0·13	..	..
Total ..	27·44	23·75	8·78	22·68	23·13	19·93	29·33	..

	Trial well near Copper Mountains, Bellary. I	Sample sent by the Chairman, Municipal Council, Bellary. II
Total solids—Grms. per litre	0·710	0·730
Volatile solids—Grms. per litre	0·070	0·090
Chlorine— Do. per litre	0·134	0·142
Total hardness—Clark's scale	8°·400	8°·050
Permanent hardness—Clark's scale	1°·400	1°·050
Free ammonia—Mlgrms. per litre	trace	0·128
Albumenoid ammonia—Mlgrms. per litre	0·032	0·036
Nitric acid, Nilgrains per litre (as ammonia)	2·550	1·650

Apparent quality of the water as inferred from the results obtained on examination.

Remarks.—The two samples are alike in all respects with two very important exceptions, viz., the variations in the "free ammonia" and in the "nitric acid." The same conditions of purity have evidently not been in existence when the two samples were drawn. In sample I the increase in nitric acid and the trace of free ammonia point to organic matter having become oxidised, while in sample II the subsequent access of fresh organic matter is indicated by the very marked rise in the free ammonia, accompanied by decrease in the nitric acid. The chlorine indication in both strengthens the suspicion that dangerous organic matter finds its way into the water. The results indicate the advisability of searching for and excluding such source of contamination.

NOTE ON THE ANALYSIS OF WATER.

Chemical Examiner's No. 681, *dated 8th July* 1896.

Sample marked II was also drawn from the trial trench, but about ten days after the work was closed. Coolies were working in the trench after the final pumping; and after the close of the work people must have had a free access to the trench. A large number of the inhabitants used to come to the work daily even when it was in progress. The impurities in II were anticipated (*vide* Sanitary Engineer's letter No. 1941, dated 22nd June 1896, to the Chemical Examiner, Madras.) Analysis I must therefore be judged by itself, independent of any considerations involved by analysis II.

Barring the chlorine and the nitric acid the water is such as may be classed as "good." The water is so highly pure with reference to the "free ammonia" and the "albumenoid ammonia" that it indicates that the chlorine and the nitric acid are of mineral origin and not organic origin and therefore harmless (*vide* McNally's Hand Book of Sanitation).

(Signed) HORMUSJI NOWROJI,
Asst. Sanitary Engineer to Government.

From J. A. JONES, Esq., MEM. INST. C.E., F.R.S.E., Sanitary Engineer to Government, to the Chemical Examiner, Madras, dated Fort St. George, 22nd June 1896, No. 1941.

Referring to your letter No. 553 of 3rd June 1896, I have the honour to forward eight bottles of water from a trial well near the Copper Mountains, Bellary, which I request you will be good enough to analyse as soon as other similar engagements will permit you which, I understand, will be about the 29th instant.

2. I am aware that the water should be examined as soon after being drawn as possible, but as the works were closed on the 19th instant, I would not have had another opportunity of collecting the sample in a state of purity and under conditions such as would obtain in the scheme for water-supply.

3. Another sample will, however, be drawn on or about the 27th instant so as to reach you about the 29th instant, and I request that both samples may be analysed at the same time and compared.

BELLARY WATER-SUPPLY.

Office-note by the Sanitary Engineer.

The experiments with reference to the Copper Hills having been now completed, it becomes the duty of the Sanitary Board to place some resolution before Government which will allow of an early decision being come to as to what scheme or what combination of schemes should be adopted so that the design therefor put in hand. The Government of India (*vide* letter of Director-General of Military Works accompanying) is desirous that some scheme should be decided on and carried out at an early date, and this note is circulated to the Board not in order that the details of any scheme be criticised but rather that the Board should recommend to Government which of the following schemes, if any, should be accepted.

2. There are now three schemes, viz.—

(1) The Hagari River Scheme.
(2) „ Copper Hills „
(3) „ Alipore Tank „

For convenience I take the Hagari scheme as first in order. The report on the Hagari scheme was sent to the Collector of Bellary and through him apparently it reached the Director-General of Military Works. The cost of this scheme is estimated

at Rs. 7,50,000, but I am not at all sure that when the scheme is worked out in detail it will be possible to limit the cost to any such amount. The scheme is a 10-gallon scheme except the pumping main, the size of which is estimated for 15 gallons. The financial one is not the only objection to the cost of this scheme. The Sanitary Commissioner has placed on record as far as I remember that this scheme should be looked on only as a last resource as the waters of the Hagari are far from chemically pure and unsuitable for drinking purposes. I may leave this point to be noted on by the Sanitary Commissioner who has made a sanitary survey of the river at the proposed offtake. As I hope to show further on, there is no advantage in the adoption of this scheme. The next scheme is the Copper Hills scheme. A full report on the experiments, &c., in regard to this scheme is attached. The Assistant Sanitary Engineer does not consider that it can safely be assumed that more than 300,000 gallons per diem can be obtained from this scheme. This is based on what is considered a low estimate from the results of the experiments made, but the experiment was for a very short period, the trench short in comparison to what would have to be constructed and it is therefore very difficult if not impossible to say what would be got from a gallery 3,000 feet long. The amount of water to be obtained would decrease, I think, very rapidly the further the gallery extends from the centre of the valley.

3. I do not therefore feel at all assured that even 300,000 gallons or 5 gallons per head could be obtained.

4. The estimate, Rs. 2,20,000 (exclusive of distribution work Rs. 1,20,000 * or a total of Rs. 3,70,000†) is, I think, also low; the gallery should be constructed above the bund and could not be merely filled with gravel as is proposed. A built gallery would add tremendously to the cost.

* This is for a 5-gallon supply and pumping from near the reservoir.
† Includes contingencies.

5. The scheme, however, might be considered as a supplemental scheme which could be constructed should scheme No. 3, which I shall presently describe, fail to deliver the required supply, and in such case the water from the Copper Hills scheme might either be pumped direct into the town or preferably into the service reservoir at A (see tracing). The routes of such pipe lines are marked on tracing accompanying.

6. I now come to the Alipore scheme; this scheme is fully described in a note by Mr. Walch, who was Chief Engineer at the time. His note is attached. My original report and all other papers are in the file forwarded herewith.

7. With reference to paragraph 8 of that note I have gone very carefully over the calculation of the inflow and outflow of the tank, and seeing that it was not likely that 15 gallons per head could be supplied, I have adopted a supply of 10 gallons per head and the evaporation of 7 feet per annum as assumed by Mr. Walch. The inflow and outflow of the tank raised 5 feet (but not extended as originally proposed) has been carefully plotted according to Rippl's method and the mass curve derived therefrom shows that even at the end of the very bad years referred to by Mr. Walch, viz., 1883 and 1884 there would still be in the tank a balance of 2·46 million cubic feet and this under the unfavourable condition of taking the tank empty at the beginning of the year 1880.

8. Mr. Walch has omitted to take into consideration the surpluses which would run to waste and of course we are now dealing with a supply of 10 gallons per head instead of 15 gallons.

9. Under the system adopted of continuous plotting of the demand and supply curves and their results, there can be no doubt that the tank, if raised, will supply Bellary with 10 gallons per head. The present tank can contain only 102 millions cubic feet with an area of 242 acres at F.T.L., while the raised tank would hold 152 millions cubic feet with 370 acres area at same level.

10. It is not a question of the benefit to be derived from the increase in capacity in the three dry years but the benefit derived during those years from the surplus amount remaining in the tank at the beginning of dry years.

11. I need not further dilate on this point, the diagrams forwarded herewith show absolutely what would have been the state of matters between 1880 and 1891 or for 12 years (including the three driest years) at which latter date the scheme was framed. Mr. Walch, it may be said, accepts the figures of the absolute supply from the areas included by the new channels.

12. The scheme as originally designed was estimated at, including establishment, Rs. 9,06,642, but if the tank be raised and not extended and other reductions be made for a supply of 10 gallons instead of 15 gallons, the estimate would stand as follows, namely, a total of Rs. 7,15,000, of which Rs. 5,67,121 would be the town share and Rs. 1,47,779 the cantonment :—

Description of works.	Cost.	Town share.	Cantonment share.
	Rs.	Rs.	Rs.
Supply channels, &c.	90,000	77,728	12,272
Raising and strengthening Alipore Tank bund ..	49,000	42,319	6,681
Extending existing sluice	600	518	82
Outlet arrangements at head of sluice	6,000	5,182	818
Engine and Boiler House	20,000	17,273	2,727
Engine Driver's quarters	6,000	5,182	818
Store shed	2,000	1,728	272
Engines, pumps and boilers including erection ..	31,850	27,507	4,343
Service reservoir	40,000	34,546	5,454
Supply and delivery of pipes	3,50,000	2,61,558	88,442
Laying and jointing	65,000	46,570	18,430
Total ..	6,60,450	5,20,111	1,40,339
Contingencies, &c. ..	54,550	47,110	7,440
Grand Total ..	7,15,000	5,67,121	1,47,779

13. If the Government of Madras made, as an exceptional case, a grant of say three lakhs and the Military of one lakh as proposed in addition to the cost of their share, the municipality would have to borrow only Rs. 1,67,121 and their actual annual expenditure would not be more than (including repayment of loan) :—

	Rs.
5·96 per cent. on Rs. 1,67,121	
Annual charges for pumping $\frac{57}{68}$ of 6,025	9,960
Do. for maintenance	5,203
	9,000
Total ...	24,163

which is well within their powers as it is said Rs. 50,000 annually could be afforded.

14. It is requested that this question may receive early attention as the Government of India is anxious for some scheme to be carried out at an early date.

Fort St. George,
29*th July* 1896.

(Signed) J. A. JONES,
Sanitary Engineer to Government.

From Surgeon-Lieut.-Colonel W. G. KING, M.B., C.M., D.PH., Sanitary Commissioner for Madras, to the Collector of Bellary, dated 15th April 1896, No. 808/S.

With reference to your letter No. 1964, dated 4th July 1895, I have the honour to state that I found the river on my inspection on the 17th February 1896, with no visible stream on the surface of the bed, although an active flow was in progress from the sub-stream in the Rupanagudi channel. Above the site from which the specimen of water had been taken, were two large areas of melon cultivation. The sandy bed of the river was found, at frequent intervals, to be covered with layers of whitish salts.

Wherever small depressions had favoured the collection of water and evaporation had followed, these salts were found the more readily. No direct entrance of drainage from any village was at time of my inspection likely, in view of the complete absence of rain for some time previously, and this would seem to correspond with the condition of affairs as found at time of taking the sample in March and May 1895.

2. An examination of the salts on the spot, without the aid of either microscope or chemical analysis, seemed to me to show that they were largely saltpetre. The chemical analysis, however, proves that I was wrong, and that there being but a trace of these salts they consisted "principally of mixed chlorides and sulphates of alkalies and of lime with small amounts of ferric oxide and alumina (nearly 6 per cent.) and nearly 35 per cent. of matter insoluble in hydrochloric acid (sand silica, &c.)." From enquiries made by me, it would seem that much of the surrounding land exhibits the presence of these salts largely, and that certain of the minor streams entering the Hagari are brackish on this account, and further that the sub-soil water as shown by the village wells is also brackish. It may thus be accepted as regards the chlorides that they do not represent previous sewage contamination. The undesirable feature to be accounted for, however, is the persistent and considerable amount of free ammonia in the three analyses. Before accepting this as due to vegetable matter undergoing change during slow passage through the river sand, it would be desirable to eliminate, as a possible cause, the mass of changing vegetable and animal organic matter represented by the melon beds, by securing a specimen of water above them for analysis. Unless these melon beds occur at small intervals up the river course, it would then be possible to pronounce the water as safe from animal contamination—the chief point to be held in mind.

3. Granting that the analysis show no marked improvement at a site higher up than that selected for specimens already examined, the water cannot be regarded as fit for domestic consumption, if delivered without preliminary treatment. This would involve the use of "Anderson's revolvers," and subsequent filtration through ordinary public water works sand filters, after lifting the whole supply from the river bed previous to subsequent forcing to Bellary. Even when thus treated, the water may be subject to much variation in composition, taking into account the fact that the condition of salt patches found on the surface of the sandy bed must be repeated layer after layer in the bed itself, and that on applying pumping in wells sunk in the sub-stream, these salts would from time to time be washed with the inflow.

4. I, therefore, consider before coming to any definite conclusion as to the advisability or otherwise of using Hagari water when compared with other possible schemes such, for example, as uniting Mr. Nowroji's sub-soil water scheme with a rainfall impounding scheme to eke out the full requirements of the town of Bellary that (1) another specimen of the water should be taken from the river at a point well above the melon beds and be sent to the Chemical Examiner for opinion; and (2) that an experiment should be conducted in imitation of treatment by Anderson's revolvers agitation with iron rivet cuttings, &c., and subsequent filtration through sand, with the object of ascertaining what grade of improvement the water would undergo after this treatment.

Office-note by the Sanitary Commissioner, dated 10th August 1896, No. 334-S.B., regarding the Bellary water scheme.

With reference to paragraph 2 of the Sanitary Engineer's note, my views are detailed in the accompanying copy of letter No. 808-S., dated 15th April 1896, addressed to the Collector, Bellary.

2. There being no doubt as to the financial capabilities of the municipality (*vide* Sanitary Engineer's note paragraph 13) to support a scheme sufficiently comprehensive to ensure not merely that water shall be supplied to the town, but that also it shall be of a quantity and quality to ensure sanitary results, I consider the scheme that should be adopted is that of uniting the Copper Hill gallery with that for the enlargement of the drainage area of the Alipore Tank.

3. As the Copper Hill supply must be regarded as supplemental to the greater impounding scheme at Alipore, and punctuality of delivery would not be essential so long as ultimate economy of the main tank supply was effected, it is worth while considering whether expenditure would not be saved by trusting to pumping from the gallery to the service reservoir by wind power.

4. Further, in considering the financial possibilities of the scheme, it is advisable to remember that if the supply is to be sanitarily safe that portion collected in Alipore Tank should be subjected to filtration before distribution, as it is obtained from an inhabited area. The Copper Hill supply would not require filtration.

No. 153-S.

Note by the President, Sanitary Board.

Three schemes have been proposed for the water-supply of Bellary, viz. —

1. The Hagari River scheme.
2. ,, Copper Hills ,,
3. ,, Alipore Tank ,,

2. The principal points to be considered in connection with these schemes are—

1. The quantity of water available.
2. ,, quality of the water.
3. ,, cost both for construction and upkeep.

3. The population of Bellary is about 66,000 and the supply required at 15 gallons per head per diem is 990,000 gallons per day or 687 gallons per minute.

4. *Hagari scheme.*—The information given regarding the quantity of water available in the Hagari is not very complete. It is stated in the Sanitary Engineer's report, dated 19th February 1895, that owing to certain facts, there is very little doubt about the sufficiency of the supply, and I agree with this opinion and think there is no doubt that the supply will be ample. As regards the quality of the water, it is stated that the popular idea is that it is good, but the Sanitary Commissioner is of opinion that the water is not fit for domestic purposes without preliminary treatment; but I think that as the water is to be collected in an infiltration gallery pumped up 235 feet through 8 miles of piping into a service reservoir and then distributed through a further length of piping, the preliminary treatment may be dispensed with, but if it is found necessary, filters may be added. As regards the cost, the estimate has been worked out for a supply of 10 gallons per head per diem though the 8 miles main has been made large enough to supply 15 gallons per head. The main, which is the most expensive item in the estimate, has been made thick enough to withstand a head of 300 feet throughout, this is unnecessary and a reduction may be effected which would go to cover the extra cost of engines. The estimate for the 10 gallons supply amounts to Rs. 7,50,000 and it is probable that a 15 gallons supply could be provided for Rs. 8,00,000.

If the Government contribute three lakhs towards the project and the Military department one lakh, the amount to be provided by the municipality will be four lakhs which represents an annual charge of Rs. 16,000.

The cost of pumping 15 gallons would be—

$$\frac{66{,}000 \times 15 \times 340 \times 365 \times 10}{1{,}000{,}000 \times 16} = \text{Rs. } 63{,}200 \text{ in round figures to which}$$

must be added Rs. 5,000 for establishment and repairs making a total of, say, Rupees 69,000.

Towards this sum the Military department will pay Rs. 10,000, therefore the cost to the municipality will be Rs. 59,000.

The annual charge to municipality will therefore be—

	Rs.
Interest on 4 lakhs	16,000
Working expenses	59,000
Sinking fund at 2 per cent.	8,000
Total	83,000

The cost of this scheme will therefore be—

	Rs.
Construction	8,00,000 * about.
Upkeep	83,000 per annum.

Copper Hills Scheme.—The quantity of water available is exceedingly doubtful as is always the case in subterranean sources, the fact that a copious supply of water has been found at one spot, such as Mr. Puttia Chetty's well, does not make it certain that a good supply will be found in the rest of the valley as a "fault" may divert the water elsewhere, although geological knowledge of the whole area from which the water is to be obtained is necessary and even then the yield is doubtful. The Assistant Sanitary Engineer has assumed that a supply of 300,000 gallons, or 5 gallons per head per diem, can be obtained, but the estimate is framed on experiments carried on for a very short period: he states that the area of the valley is 9 square miles and that if 50 per cent. of the lowest rainfall, viz., 7·34 inches be assumed to be stored below ground, the yield would be 73 millions cubic feet; the yield reckoned on by him being less than 18 millions cubic feet. Fanning, in his book on Water-supply, states that in a district where the mean annual rainfall is 40 inches, the percolation into one square mile of porous soil in dry years is 12·5 millions cubic feet per annum and that for the quantity received into well or springs in that area it would seldom be safe to take more than from 10 to 20 per cent. or, say, 1·5 million cubic feet, so the yield from the 9 square miles of the Copper Mountain valley would only be 13·5 million cubic feet, but the mean annual rainfall in Bellary is only about 18 inches so that probably not more than 5 or 6 millions cubic feet could be obtained in a year of drought.

The quality of the water is apparently good and will require no preliminary treatment.

The cost of the scheme will be Rs. 3,70,000, the working expenses about Rupees 23,000.

Alipore Tank Scheme—Quantity.—According to the Sanitary Engineer the tank, if enlarged, would hold sufficient for a supply of 10 gallons per head, and the run-off from the catchment will be sufficient to fill the tank with the increased capacity. The accuracy of this of course depends on the assumed run-off, and Mr. Jones has apparently taken Nagpore as an example, but I consider that the supply is doubtful.

Quality.—I can find nothing in the papers regarding the quality of the water.

Cost.—Mr. Jones estimates the cost at Rs. 7,15,000, if out of this sum Government provides Rs. 3,00,000 and the Military Department Rs. 1,00,000, the sum to be provided by the municipality will be Rs. 3,15,000:—

	Rs.
Interest on Rs. 3,15,000 at 4 per cent.	12,600
Sinking fund at 2 per cent.	6,300
Charge for pumping	5,203 †
Do. for maintenance	9,000
	33,103

say, Rs. 33,000. This figure differs from Mr. Jones, as I cannot find anything in the papers to show that the Military Department will pay one lakh of rupees in addition to their share, so I have taken the contribution for it to be only one lakh as in the case of the Hagari scheme.

* If, however, a 10-gallon scheme is adopted, the initial cost will be about Rs. 7,00,000 and the working expenses to be borne by the municipality Rs. 55,000.

† See Mr. Jones' figures.

In his note, dated 10th August 1896, the Sanitary Commissioner advocates a combined Alipore tank and Copper Mountains scheme. Now the cost of the former is Rs. 7,15,000 and of the latter Rs. 3,70,000, total Rs. 10,85,000, supposing Government and Military Department to provide four lakhs between them, the interest and Sinking fund at 6 per cent. on the balance, viz., Rs. 6,85,000, will be Rs. 41,100. The pumping expenses from the tank alone are Rs. 5,203 and double pumping would, I presume, be required, so that the working expenses would not fall short of Rupees 60,000, and for this expenditure a supply of not much over 10 gallons a head would be obtained.

To sum up we have—

Hagari Scheme.—Quantity, ample for 15 gallons or more. Quality, good on delivery—

	Rs.
Capital cost	7,00,000 *
Working expenses	55,000 *

Copper Mountain Scheme.—Quantity, altogether insufficient. Quality, good—

	Rs.
Capital cost	3,70,000
Working expenses	23,000

Alipore Tank Scheme.—Quantity, doubtful. Quality, not known—

	Rs.
Capital cost	7,15,000
Working expenses	33,000

Combined Alipore Tank and Copper Mountain Scheme.—Quantity, sufficient for 10 gallons supply. Quality, not known—

	Rs.
Capital cost	10,85,000
Working expenses	60,000

The capital cost given in each case is total cost, while the working expenses are only those to be borne by the municipality.

After carefully considering all the schemes I am of opinion that the Hagari river—one giving a supply of 10 gallons a head—is the best; it possesses the advantage of having a certain supply and being able to increase that supply to 15 gallons a head, should that be found necessary hereafter and none of the other schemes possess these advantages, I therefore consider that the Hagari scheme should be worked out in detail.

(Signed) D. McNEIL CAMPBELL, Colonel, R.E.,
President, Sanitary Board

To the Sanitary Engineer,
with papers, in original, returned.

Note by the Sanitary Engineer to Government.

[*Reference.*—Note by the President, Sanitary Board, No. 153-S., dated 2nd October 1896.]

The Hagari Scheme.—The estimate of Rs. 7,50,000 for this scheme in the report, dated 19th February 1895, must be considered only as an approximate estimate, though it was as near an approximation as possible with the information then available. Since then survey and levels have been taken for the Hagari scheme and the proper site for the head works has been located. It is now found that the actual lift, exclusive of frictional head in the pipes, is 240 feet against 235, and that the actual length of the main will be 50,000 feet instead of 42,080 feet (8 miles) assumed originally. The original length was measured off a plan, 1 inch = 1 mile.

* At 10 gallons a head.

2. The size proposed for the pumping main is 12 inches, which requires a hydraulic grade of 2 in 1,000 to deliver 687 gallons per minute (15 gallons supply). The head required in a length of 50,000 feet will be 100 feet and the total lift will therefore be 240 + 100 = 340 feet. In the President's note an error has crept in by assuming for the 15 gallons scheme the same lift as in the 10 gallons scheme. The total lift in the 10 gallons scheme will now be 285 feet.

3. The thickness of the main should of course be calculated for a 15 gallons supply as eventually it is expected to carry this quantity. The following table gives the thickness of pipes (and weight) necessary for various heads in a 12-inch pipe (see Fanning):—

Head.	116 Feet.	230 Feet.	300 Feet.	340 Feet.
Thickness *	$\frac{9}{16}$″	$\frac{5}{8}$″	$\frac{11}{16}$″	$\frac{3}{4}$″
Average weight per foot .. cwt.	·69	·76	·83	·90

By plotting the hydraulic gradient of the pumping main, it is found that the pipe should have the following thickness for the lengths noted opposite to them:—

For 9,000 feet, $\frac{9}{16}$″.
For 21,000 „ $\frac{5}{8}$″.
For 15,000 „ $\frac{11}{16}$″.
For 5,000 „ $\frac{3}{4}$″.

Total ... 50,000 feet.

4. The cost of the main will now be Rs. 2,94,000 in round figures.

The cost of the Hagari scheme, as revised, will now be approximately as follows:—

Description of work.	Fifteen gallons supply.	Ten gallons supply.
	Rs.	Rs.
Infiltration works	50,000	50,000
Engine house, drivers' quarters, store-shed, land, fencing, &c.	50,000	50,000
Engines and pumps	96,000	75,000
50,000 feet of 12-inch pumping main pipes	2,94,000	2,94,000
Service † reservoir	75,000	50,000
Distribution system	2,15,000	2,15,000
Total ...	7,80,000	7,34,000
Contingencies	70,000	66,000
Grand Total ...	8,50,000	8,00,000

It is assumed that the Government is prepared to contribute at least 3 lakhs towards any scheme for the water-supply of Bellary, and if the Military Department make a grant of 1 lakh, the municipality will have to provide 4·5 lakhs in the 15 gallons scheme and 4 lakhs in the 10 gallons scheme which represents Rs. 27,000 and Rs. 24,000 annually for interest and Sinking fund.

5. The pumping charges will be for the 15 gallons scheme—

$$\frac{66,000 \times 15 \times 340 \times 10 \times 365}{1,000,000 \times 16} = \text{Rs. } 77,000 \text{ in round figures.}$$

In the 10 gallons scheme the pumping charges will be—

$$\frac{66,000 \times 10 \times 285 \times 10 \times}{1,000,000 \times 16} = \text{Rs. } 43,000.$$

* No reduction is possible in the thickness given. They are thicknesses from actual calculations. In American practice much greater thickness is given in direct pumping schemes. For instance, Fanning gives a case where a 12-inch pipe, $\frac{1}{8}$ inches, has been used for only a head of 260 feet.

† The service reservoirs provided in estimate are of 1½ days' capacity. A three days' storage is advisable in this scheme considering that the main is over 9 miles in length under a maximum pressure of 340 feet.

The total cost to the municipality on the assumption that Military Department will pay Rs. 10,000 towards pumping charges will be—

	Ten gallons scheme.	Fifteen gallons scheme.
	Rs.	Rs.
Interest and Sinking fund	24,000	27,000
Pumping charges	33,000	67,000
Maintenance of pipes, &c.	5,000	5,000
Total ...	62,000	99,000

6. In the estimates for the Hagari scheme no provision is made for the military distribution system. The cost of this, *i.e.*, about Rs. 1,70,000 (*vide* letter from the Director-General of Military Works, No. 1034 B., dated 16th April 1896), the Military Department is prepared to incur in addition to the contribution of 1 lakh towards the general scheme. The Hagari scheme will therefore cost the Military Department an initial outlay of Rs. 2,70,000 and an annual expenditure of Rs. 10,000 pumping, *plus* Rs. 2,000 maintenance of pipes in cantonment.

7. *Copper Hills Scheme.*—The work proposed is a continuous trench across the valley, and under such circumstances, according to Fanning, it should be possible to obtain 50 per cent. of the quantity of water absorbed or, say, 3 millions cubic feet per square mile, which equals to about 27 millions cubic feet for the whole drainage area, while the yearly yield reckoned at 300,000 gallons per day amounts to only 18 millions cubic feet. Again a factor of no little importance which has to be reckoned in calculating the yield is the tank which the scheme provides at the gallery, which will hold about 74 millions cubic feet. The tank will retain the greater portion of the rainfall which at present drains off the area and in dry weather it will feed the underground springs.

8. The cost of the scheme, including distribution independent of any other scheme, will be Rs. 3,70,000 (*vide* Sanitary Engineer's and Chief Engineer's notes).

9. The pumping charges will be $\frac{300,000 \times 365 \times 40 \text{ (lift)} \times 10}{1,000,000 \times 16} = \text{Rs. } 2,800.$
Assuming that Government will contribute a moiety of the cost, the annual cost to the municipality will be—

	Rs.
Interest and Sinking fund on Rs. 1,85,000	11,100
Pumping charges	2,800
Maintenance of pipes	3,100
Total ...	17,000

It is not apparent how the figure of Rs. 23,000 in the President's note was arrived at.

10. The estimate of Rs. 3,70,000 includes cost of distribution pipes in the town of Bellary (exclusive of the cantonment) for a delivery of 10 gallons per head. If combined with the Alipore scheme, the cost of the supply from the Copper Hills will be only Rs. 2,20,000 instead of Rs. 3,70,000, as the Sanitary Engineer's estimate in his note on the Alipore scheme includes complete distribution in the town and cantonment for a 15 gallons scheme.

11. *Alipore Tank Scheme.*—The question as regards the quality of the water in the Alipore tank has never been raised before, though the scheme has been under consideration for years past. The water has always been considered good. There is no doubt that it is so and far superior to the Hagari water.

12. In calculating the cost of this scheme to the municipality the President takes the contribution from the Military Department as 1 lakh, but in the Sanitary Engineer's memorandum the share of the Military Department is calculated at Rupees 1,47,000. If, however, the Military Department is not prepared to contribute any more than its equitable share of cost, the annual cost to the municipality will be as under—

	Rs.
Interest and Sinking fund on Rs. 2,67,221	16,000
Pumping charges	5,203
Maintenance	9,000
Say	30,000

In this scheme provision is made for pipes in the cantonment but not distribution in barracks. The latter will cost about Rs. 70,000. The cost to the Military Department in the Alipore scheme will be—

	Rs.
Initial cost—	
Contribution towards the general scheme including pipes in cantonment	1,47,000
Additional for distribution in barracks, &c.	70,000
Total ...	2,17,000
Annual cost—	
Pumping	1,000
Maintenance of pipes	2,000
Total ...	3,000

14. *Combined Alipore Tank and Copper Mountain Scheme.*—The cost of this scheme will be—

	Rs.
Alipore tank scheme	7,15,000
Copper Hills scheme	2,20,000
Total ...	9,35,000

The pumping charges will be—

	Rs.
Alipore tank supply	6,025
Copper Hills supply	2,800
Total ...	8,825

The military share of the pumping charges in the combined scheme will be about Rs. 1,000, or Rs. 9,000 less than in the Hagari scheme. Rs. 9,000 capitalised at 3 per cent. represents 3 lakhs. If the Military Department contributes to the municipality Rs. 2·5 lakhs in the case of the combined scheme, the expenditure to them will still be less than in the Hagari scheme.

15. Government will contribute 3 lakhs. The amount the municipality has to provide will in such case be 3·85 lakhs.

16. The cost of the combined scheme to the municipality will be—

	Rs.
Interest and Sinking fund on 3·85 lakhs	23,000
Pumping charges (less 1,000 to military)	7,825
Maintenance	9,000
Say	40,000

17. The cost to the Military Department in the combined scheme will be—

	Rs.
Initial cost—	
Contribution to municipality including pipes in cantonment ...	2,50,000
Distribution within barracks	70,000
Total ...	3,20,000
Annual cost—	
Pumping charges	1,000
Maintenance of pipes	2,000
Total ...	3,000

18. Comparing the Hagari scheme (10 gallons) and the combined Alipore and Copper Hills scheme, the statement as regards the municipality and the Military Department stands thus:—

	Municipality. Rs.	Military Department. Rs.
Annual cost—		
Hagari scheme (10 gallons)	62,000	16,510 *
Combined Alipore and Copper Hills schemes	40,000	12,600 *

19. The undersigned notes that the President states that the quality of water of the Hagari will be good when pumped from wells; there is no ground for this statement and though it may turn out to be so it is doubtful, considering the pollution the Sanitary Commissioner has found which is not one likely to be removed by natural sand filtration. The Sanitary Commissioner is, it is understood, greatly opposed to the use of Hagari water if any other source can be adopted and it is therefore a question whether he is prepared to consider the Hagari scheme at all under the circumstances.

20. The undersigned favours the Alipore scheme supplemented if it is found insufficient by the Copper Hills scheme, especially as it is a cheaper one, and the water is purer, while the Sanitary Engineer himself believes the quantity will be perfectly sufficient.

(Signed) J. JONES,
Sanitary Engineer to Government.

From Surgeon-Lieutenant-Colonel W. G. KING, M.B., C.M., D.PH., Sanitary Commissioner for Madras, to the Collector of Bellary, dated Fort St. George, 25th September 1896, No. 1764/S.

With reference to your endorsement, No. 901, dated 18th September 1896, upon report by the Chemical Examiner of the water from the river Hagari, I have the honour to request you will kindly inform me of the date and site of collection, and will add information as to whether the melon beds referred to in my letter No. 808/S, dated 15th April 1896, existed at time of collection.

Ref. on C. No. 901.

True copy communicated with Sanitary Commissioner's No. 808/S. to the Chairman, Municipal Council, Bellary, for favour of early compliance.

(Signed) J. T. LEVER,
for *Collector*.

1*st October* 1896.

* Including interest on capital charges at 3 per cent.

The day on which the water was collected from the bed of the river Hagari was on the 18th of August last and the site was about 152 yards to the south of the bridge in a line with the 4th pile, there were no melon beds existing at the time of collection. The Tahsildar of Bellary was present at the time when the water was collected.

(Signed) E. FAIRMAN,
Sanitary Inspector, Brucepet.

8*th October* 1896.

Enclosure.

A.

	Irrigation channel water near Rupanagudi.	Spring water taken in the bed of the Hagari river near Rupanagudi.
Total solids, grms per litre	0·670	0·400
Volatile solids, „ „	0·120	0·080
Chlorine, „ „	0·168	0 060
Total hardness Clark's scale	5°·775	3°·850
Permanent hardness „	Trace.	Trace.
Free ammonia, milgrms per litre	0·088	0·096
Albuminoid ammonia „ „	0·176	0·192
Nitric acid „ „ (as ammonia)	Trace.	Trace.
Apparent quality of the water as inferred from the results obtained on examination	Suspicious.	Suspicious.

(Signed) W. G. KING, Surgeon-Lt.-Col.,
Sanitary Commissioner.

B.

	Hagari water.
Total solids, grms per litre	0·230
Volatile solids „ „	0·160
Chlorine „ „	0·019
Total hardness, Clark's scale	1°·575
Permanent hardness „ „	0°·350
Free ammonia, milgrms per litre	Trace.
Albuminoid ammonia „	0·032
Nitric acid „ (as ammonia)	0·270

Apparent quality of the water as inferred from the results obtained on examination usable—very much better than the last sample. Examined and reported on in my No. 638, dated 17th June 1895.

The water contained fine river mud, and so it was filtered through ordinary filted paper before examination. As the water will, no doubt, be passed into settling tanks or through filted beds before distribution for supply, the above proceedings does not make any important difference in the estimation of the water for potability.

(Signed) J. L. VAN GEYZEL,
Chemical Examiner.

No. 443-S.B.

Note by the Sanitary Commissioner for Madras.

[*Subject*—Bellary Water-supply.]

[*Reference.*—This office-note, No. 334 S.B., dated 10th August 1896, forwarding copy of this office letter, No. 808 S., dated 15th April 1896.]

I forward, for information, copy of the analysis (*a*) discussed in the above reference, and one since made, (*b*), dated 18th September 1896, but only received by me on the 14th instant.

2. It will be seen that my suggestion that the organic contamination may be due to the melon beds is correct. These beds having ceased to exist probably since June, their influence to the marked extent formerly apparent, is not now exhibited.

So far, the result is satisfactory; but in view of the notorious mawkishness of the water (the municipality, in their address to His Excellency the Governor lately described it as "brackish"), the existence on the bed of the river of large deposits of salts recognized as *sulphates* of the alkalies—a most undesirable form—and the nature of the surrounding land, I consider it would be erroneous to determine to use this source without going to the further test of ascertaining to what extent the quality of the water varies with the season. In my opinion it will be found to be unfavourably influenced after moderate rainfalls. The test now required is that by sinking a well in the river-bed or by boring, it should be ascertained after vigorous pumping for several days, during the early part of the monsoon, how far the salts are brought into solution from the sub-soil and surface. In sinking the well, the nature of the sand as to salt deposits should also be examined.

3. In regard to the President's proposal to trust to purification during transit in pipes, it must be remembered that whilst albuminoid ammonia is thus advantageously affected—giving, however, the consumer an equivalent dose of nitrates — it does not follow that the pipe system of distribution is a safe locality for purification to be effected. As regards salts in solution, neither this nor the passing through the sand of the gallery would ultimately have material effect on the amount. But, by the use of Anderson's revolvers, as suggested by me, both a deprivation of organic constituents and an appreciable benefit in salt constituents would have been obtained before pipe entry. However, this suggestion need not now be discussed, as it was made in the eventuality of the Hagari water proving still "suspicious" *after removal of the melon beds*. If the water gives as good results on the application of the test suggested in paragraph 2 as on the last analysis, (B), it would not be essential to undertake any purification process before distribution.

4. I invite the attention of the President to the result of the first analysis as to organic contaminations at a site about 500 yards below the melon beds and that now obtained, when these were no longer in existence, with the suggestion that it should shake his trust not only in the purification from organic constituents he expected in this instance from so-called filtration through a gallery in a saturated mass of sand of a river-bed, but in reference to similar conditions in the Bezwada supply.

5. As to the Alipore tank-supply, no analysis has been provided. It should have been procured before this stage of the discussion. I, however, fully agree with the Sanitary Engineer to Government that there exist no *primâ facie* grounds why this water should not be of good quality—provided storage is conducted with care. Analysis of the Copper Hill infiltration gallery has already shown this to be good.

Fort St. George,
22*nd October* 1896.

(Signed) W. G. KING, Surgeon-Lt.-Col.,
Sanitary Commissioner.

Note by the President, Sanitary Board.

I am still in favour of the Hagari scheme as giving a more certain supply than the others. I consider certainty of supply is quite as important as the quality of the water, for in the event of a failure, the people would have to fall back on their old disused sources of supply such as wells which would have become foul. Moreover, the latest analysis of the Hagari water shows that it is usable. This analyses differs considerably from the first and their is, no doubt, that analysis taken out at different times of the year would all give different results. I have seen the bottles of water taken from the same part of the same tank and at the same time and the water in each gives a different result when analysed. My opinion that the water would get purer by being pumped up through a considerable length of piping was based on some experiments I had made at Mysore; water that was chemically bad was passed through only a short length (I think about two miles of piping) and was found afterwards to be much purer. The working expenses of the Hagari scheme are, no doubt, very high and if beyond the means of the municipality, the only resource is to carry out the Alipore scheme to be afterwards supplemented, if necessary, by the Copper Mountain scheme.

I am doubtful about the supply from the Alipore tank for in a district with an average rainfall of only 17 inches the run off will be very small, and, in some years, practically nothing and it is hardly safe in such circumstances to trust to impounding reservoirs.

The uncertainty of supply in subterranean schemes is well known and with such a low rainfall the uncertainty is still greater and I think it probable that in years like 1884 and 1891 when the rainfall was only 5·79 inches and 8·46 inches, respectively, hardly a drop of water would reach the gallery.

The working expense for the Hagari scheme giving a supply of 15 gallons is Rs. 99,000 as given by Mr. Jones; this is no doubt beyond the means of the municipality but for the 10 gallons scheme the working expenses are only 62,000 and it could probably afford that sum—and the supply might, after some years, be increased to 15 gallons which would not be the case as regards other schemes, for I cannot accept the conclusion that the Alipore and Copper Mountain schemes combined would give a supply of 15 gallons per head.

(Signed) D. McNEIL CAMPBELL, Col., R.E.,
President, Sanitary Board.

Proceedings of the Sanitary Board, dated 14th November 1896, No. 247 S.

Read—the following papers:—

G.O., Mis. No. 1010 M., dated 15th June 1896.

Note by the Sanitary Engineer, dated 29th July 1896.
Do. Sanitary Commissioner, No. 334 S.B., dated 10th August 1896.
Do. President, Sanitary Board, No. 153 S., dated 2nd October 1896.
Do. Sanitary Engineer, dated 12th October 1896.
Do. Sanitary Commissioner, No. 443 S.B., dated 22nd October 1896.
Do. President, Sanitary Board, dated 30th October 1896.

Resolution.—The Government of India having in their letter, No. 1342 M.W., dated 16th May 1896, called for a definite scheme for the provision of a pipe water-supply for the town and cantonment of Bellary prior to considering the question of a grant from Imperial funds on account of the cantonment supply, the papers were communicated in G.O., Mis. No. 1010 M., dated 15th June 1896, to the Sanitary Engineer and the Municipal Council, Bellary, for the requisite action.

2. The following four schemes have now been laid before the Sanitary Board:—

(1) The Hagari river scheme.
(2) The Copper Hills scheme.
(3) The Alipore tank scheme.
(4) A combination of (2) and (3).

3. In his notes of the 2nd and 30th October 1896, the President reviews these schemes, and the Board, concurring in his view as to the superiority of the Hagari scheme, resolves to recommend it to Government.

(True Extract.)

(Signed) R. PARSONS,
Secretary, Sanitary Board.

From J. A. JONES, Esq., mem. Inst. c.e., f.r.s.e., Sanitary Engineer to Government, to the Secretary to Government, Local and Municipal Department, dated Fort St. George, 2nd February 1897, No. 207.

In reply to your Memo., No. 93 of 30th January 1897, I have the honour to inform you that there is no irrigation under the Alipore tank. It is a tank belonging to the Military department and used for feeding Fisher's tank and the fort ditch from time to time for the use of the troops.

From H. A. STUART, Esq., Acting Collector of Bellary, to the Secretary to Government, Local and Municipal Department, dated 8th February 1897, Dis. No. 778.

In reply to Government Memo., No. 92 of 30th January 1897, I have the honour to state that the Alipore tank, Bellary taluk, is not used for irrigation purposes, and has no ayacut under it. The tank is used as a resevoir for the water-supply to Bellary town.

2. An estimate for the improvements of this tank at a cost of Rs. 81,900 has been included in the programme of famine-relief works revised up to end of December last. The estimate was prepared by the Sanitary Engineer, Madras, during the famine of 1891-92 and Government in the Public Works Department in its order, No. 1367 W., dated 2nd May 1892, directed the Superintending Engineer, III Circle, to submit a revised estimate with reference to the note by the Chief Engineer for Irrigation printed in the Government Order quoted above. The Superintending Engineer, III Circle, stated in his letter, No. 602, dated 20th May 1892, that the revised estimate called for by Government was submitted by him. The records in this office do not show as to what further action has been taken by Government in the matter. The work has been included in the programme of famine-relief works in accordance with the orders of the Board of Revenue in its Proceedings, Mis. No. 2025, dated 26th February 1892.

Order—No. 1463 M., dated 21st June 1897.

The Government is of opinion that the Alipore tank and the Copper Hills schemes for bringing water to the town and cantonment of Bellary must be abandoned owing to the uncertainty of the supply. This leaves for consideration the Hagari scheme, which as recommended by the Sanitary Board in its Proceedings read above, His Excellency in Council is prepared to approve. The Sanitary Engineer estimates the initial cost of this scheme for a supply of 10 gallons per head of the population, which the Government considers should be the minimum quantity for a town like Bellary, at eight lakhs of rupees, exclusive of 1·7 lakhs required for laying down pipes within the cantonment, while the annual charges on account of maintenance and pumping, which will be incurred by the municipal council and the Military department, are put at Rs. 38,000 and Rs. 12,000, respectively. Even with the extended powers of taxation given by the District Municipalities Amendment Act of 1897, the financial resources of the municipal council will not allow of its contributing or borrowing any material proportion of the cost of the construction of the works, and all that it can afford to pay will be its share (Rs. 38,000) of the annual maintenance and pumping charges. As matters stand at present in regard to the Provincial finances, the Government cannot promise any definite grant-in-aid within any definite period. His Excellency in Council communicates this decision to the municipality with much regret. The Government of India will, at the same time, be informed that if the introduction of the water-supply scheme is urgently required in the interests of the military population residing within the cantonment, the whole capital for the construction of the works must be provided from Imperial funds, since there is no other source from which it is possible to find it.

(True Extract.)

for Secretary to Government.

To the Sanitary Board.
„ the Sanitary Commissioner.
„ the Sanitary Engineer.
„ the Collector of Bellary.
„ the Chairman, Municipal Council, Bellary.
„ the Public Works Department.

Exd. Md. Pahilvan.

Sec

Public Works Department.

Government {1897} of Madras.

LOCAL AND MUNICIPAL.

Recd. } 1897. *Enclosures*

Regd. } *Spare copies*

G.O., No. 1463 M., 21st June 1897.

No 2302 dated 21.8.97
communicated to the
S.E. III circle.
Hdg D No. C
W

JUNE.

To
The S.E. III circle.

Bellary Water-supply Scheme.

Considering that the Alipore tank and the Copper Hills schemes for the water-supply of Bellary must be abandoned owing to the uncertainty of the water-supply and that the Hagari scheme which the Government is prepared to approve is beyond the means of the municipal council, and informing the municipal council with regret that, as matters stand at present in regard to Provincial finances, the Government cannot promise any grant from Provincial funds towards the last-mentioned scheme within any definite period.

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ—again the following papers:—

G.O., Mis. No. 93 M., dated 23rd January 1893.

ABSTRACT.—Referring to the Municipal Council, Bellary, with remarks, memorandum of the Chief Engineer, Public Works Department, regarding the water-supply scheme of Bellary.

G.O., Mis. No. 483 M., dated 10th April 1893.

ABSTRACT.—Stating that the Bellary water-supply scheme may be considered as finally abandoned.

GO., Mis. No. 1469 M., dated 9th September 1895.

ABSTRACT.—Sanctioning the allotment of Rs. 2,000 required by the Bellary Municipal Council for the investigation of the Copper Mountain water-supply scheme.

G.O., Mis. No. 1936 M., dated 22nd November 1895.

Read—the following letter from the Secretary to the Government of India, Military Department, to the Secretary to the Government of Madras, Local and Municipal Department, dated Simla, 2nd November 1895, No. 2837 M.W. (Cantonments—Water-supply):—

I am directed to forward, for the information of His Excellency the Governor in Council, a copy of the letter marginally noted from the Director-General of Military Works, relative to the provision of a pipe-water supply for the city and cantonment of Bellary and to observe that the question of the water-supply for this station has been for a very long time under consideration. I am therefore to request that, under His Excellency's orders, the local authorities may be urged to take steps towards securing an early settlement of the question.

No. 2891 B., dated the 4th October 1895, and enclosure.

ENCLOSURES.

Copy of a letter from the Director-General of Military Works, to the Secretary to the Government of India, Military Department, dated 4th October 1895, No. 2891 B.

With reference to Military Department letter, No. 1593 M.W., dated 25th May 1893, I have the honour to forward herewith a copy of a preliminary report and rough approximate estimate amounting to 7½ lakhs, prepared by the Sanitary Engineer to the Madras Government, on a scheme for supplying the city and cantonment of Bellary with water from the Hagari river, distant about 8 miles from cantonments.

O. 1463

The Sanitary Engineer has also prepared a rough scheme for a supply from wells sunk in the sloping ground at the foot of the Copper Mountain, the cost being estimated at 5 lakhs.

I do not forward a copy of this last-named scheme, because it is acknowledged that the available data are too meagre to allow of a correct forecast being made of the quantity and quality of water that can be obtained from this source. The municipality have, however, allotted a sum of Rs. 2,000 with a view to a further investigation of this Copper Mountain scheme.

So far as my information goes, the most promising source of supply for the city and cantonment is the Hagari river, and from paragraph 3 of the Sanitary Engineer's report it will be seen that little doubt is entertained locally as to the sufficiency of its yield of water.

2. Turning now to the proposals put forward in the Sanitary Engineer's report, I observe that he recommends a provision of 15 gallons per head per diem for a combined civil and military population of 66,000 souls. The scale of 15 gallons all round appears to me excessive. Taking our experience in other cantonments as a guide, the total quantity of water required for the military population would be 65,000 gallons per day, made up as follows:—

1,039 Europeans	at 15 gallons per day	...	...	15,585
5,227 Natives	at 8 „ „	...	...	41,816
741 houses	at 10 „ „	...	...	7,410
	Total	...		64,811
	(Say)			65,000 gallons.

In this connection, I may mention that at Peshawar and elsewhere it has been found by practical test that 5 gallons per head per diem amply suffices to meet the wants of a native family.

3. In paragraphs 13 and 14 of his report the Sanitary Engineer calculates on a contribution of one lakh of rupees from the Military Works Department towards the initial cost of the scheme, and 3 lakhs from the Local Government. The total working charges (exclusive of interest) are estimated at Rs. 48,000 per annum.

Further, in paragraph 17, it is asserted that the inclusion of the barracks and Native Infantry lines in the scheme entails the whole of the town supply being lifted 30 feet higher than the requirements of the town demand. The charge for this additional lift is worked out to be Rs. 5,000 annually, which amount the Sanitary Engineer considers should be borne by the Military Department, exclusively. This would leave a balance of Rs. 43,000 for the annual pumping charges which it is proposed shall be shared by the Municipality and Military Department, in the proportion of the population, taking the military population at one-eleventh of the whole. Hence the proposed military share would be Rs. 5,000 for the additional lift *plus* $\frac{1}{11} \times$ Rs. 43,000 = Rs. 4,000, that is, a total of Rs. 9,000 per annum approximately.

To sum up: the Sanitary Engineer reckons on an initial contribution of one lakh of rupees from the Military Works Department, and 3 lakhs from the Local Government towards the capital cost, and a payment of Rs. 9,000 annually by the Military Department. It is hoped that the balance of the annual charges for pumping and interest will be covered by taxes, but on this point the Sanitary Engineer is not sanguine.

4. With regard to these proposals I fail to see any special reason for treating the Bellary scheme differently from those for Agra, Allahabad, &c. Consequently I do not recommend that any fixed annual sum be contributed towards the extra cost of the municipal headworks and mains due to the supply required for the cantonment. This extra cost should be covered by the price charged by the municipality for the water supplied to the cantonment.

The Military Department should only pay a certain rate per thousand gallons for water supplied as is done in the case of Agra, Delhi, Allahabad, and as has been proposed and accepted for Lebong.

Again, instead of an initial contribution of one lakh of rupees, the Military Works Department should provide or meet the cost of all reservoirs, distribution pipes, &c., required from beyond the point where the cantonment scheme will take off from the municipal main.

5. In paragraph 20 of his report, the Sanitary Engineer suggests that the municipality should levy a water-tax on private houses in the cantonment. This proposal is inadmissible as, whatever the powers of the municipality may be outside cantonment limits, that body have no authority to levy a water-tax within those limits, especially as the water supplied to the cantonment will be paid for at a certain fixed rate.

6. It is evident from the general tenor of the Sanitary Engineer's report that there exists some doubt whether the municipality of Bellary will be able to find the funds for their share of the work on the Hagari project, and it is, I am informed, mainly for this reason, that the investigation of the Copper Mountain source has been undertaken. Meanwhile, the Hagari scheme is in abeyance.

Should the Copper Mountain scheme prove to be practicable at a moderate cost, the municipality will doubtless be advised to accept it. If, on the other hand, the investigations show that sufficient water is not available at the base of the Copper Mountain, then the Hagari river project for water-supply to the cantonment and town should be worked out in detail without further delay.

In conclusion, I would suggest the expediency of pressure being brought to bear on the municipality through the Madras Government, with a view to an early settlement of the source of supply and the commencement of work on the one scheme or the other.

Report on the Bellary Water-Supply by the Sanitary Engineer to Government.

The Hagari Scheme.

The source of supply as proposed by Mr. Tremenheere is underflow in sandy bed of the Hagari river at a point close to the Hagari station on the Southern Mahratta Railway, which is, as the crow flies, about 8 miles from the Bellary Club. The scheme briefly is, to collect the underflow in Hagari in the best manner possible; to pump the water into service reservoir placed on the high ground on which the Bellary Club stands; and finally to distribute the water throughout the town and cantonment in the usual manner with pipes and fountains.

2. *Quality of water.*—The Hagari water has not been analysed. The popular opinion is that it is a good water; the villagers on the bank of the river drink its water. A fair idea of the quality of the Hagari water would be obtained by having the water of the railway well at Hagari analysed. This well is close to the margin of the river. I have made this suggestion to the Collector.

3. *Quantity of water.*—The Hagari is about 2,500 feet broad at the place it is proposed to tap it. It has a very deep sandy bed. The iron cylinders of the railway bridge are said to have been sunk 200 feet deep. From enquiries made of the villagers on the bank it appears that the dry weather level of water never falls more than 6 feet below the surface of the bed. A spring-channel that takes its rise a little above the village of Hagari is reported to have been flowing even during the famine of 1877. Taking these facts into consideration, there is little doubt about the sufficiency of water.

4. *Quantity of water required.*—The civil and military population is about 66,000. A provision of 15 gallons per head per diem should be made. The Collector considers that a provision of 10 gallons would be ample. This would no doubt be so for the first few years after the introduction of the scheme. But it is very likely that, within a period which will be very small compared with the life of the works, the consumption would exceed 10 gallons. As the pumping main will be about 8 miles in length, any future attempt to increase the supply from 10 to 15 gallons will involve a very considerable outlay. It will, therefore, be cheaper in the long run to make the delivery

main large enough to carry a supply calculated at 15 gallons per head. The pipe should therefore be capable of delivering $66,000 \times 15 = 990,000$ gallons per day of 24 hours = 687 gallons per minute.

5. *Pumping main.*—A 12-inch pipe with a hydraulic gradient of 2 in 1,000 will give the above supply. The weight per foot of 12-inch pipe to stand a head of 300 feet = 75 cwt. A mile of 12-inch piping at Rs. 150 per ton laid complete would cost Rs. 30,000.

6. *Lift.*—The bed of the Hagari is 215 feet below the ground near the Bellary Club, where it is proposed to construct the service reservoir. To this must be added 5 feet, level of water in reservoir above ground, and 15 feet, level of inlet to pumps below bed of the Hagari. The actual height to which water has to be lifted will be 235 feet.

7. Loss of head by friction through 8 miles of piping $8 \times 5,282 \times 2 = 85$ feet.

8. The total lift on the head against which pumps will have to work will be $235 + 85 = 320$ feet.

9. The consumption for some years to come will not exceed 10 gallons or $\frac{10}{15} \times 687$, say 460 gallons per minute. The head required to pass 450 gallons through a 12-inch pipe is 1·1 in 1,000, or say 50 feet in 8 miles of piping. The total lift in this case would be $235 + 45 = 280$ feet.

10. *Pumping power.*—For a supply of 10 gallons per head $\frac{460 \times 280 \times 10}{33,000} = 39$ pump horse-power, would be required, or 3 engines of 13 pump horse-power each; add one as a reserve engine; total required, 4 engines of 13 pump horse-power each.

11. *Estimate of works.*—The following is an approximate estimate of the scheme:—

		Rs.
Infiltration works		50,000
Engine house, Engine driver's quarters, store-shed land, &c. ...		50,000
Engines and pumps (4 of 13 P.H.P. each)		75,000
8 miles of 12″ C.I. pipes		2,40,000
Service reservoir		50,000
Distribution system		2,15,000
	Total ...	6,80,000
Contingencies		70,000
	Grand total ...	7,50,000

12. *Cost of pumping.*—Cost of pumping 10 gallons per head per diem for a population of 66,000 at 10 annas per million gallons lifted one foot high, would be $\frac{66,000 \times 10 \times 280 \times 365 \times 10}{1,000,000 \times 16}$ = say Rs. 43,000. To the above must be added Rs. 5,000, annual cost of establishment, repairs, &c., to the distributary system. The total working charges would be Rs. 48,000, exclusive of interest and sinking fund on the initial outlay.

13. *Allocation of charges.*—Calculating roughly, not more than a lakh of the initial cost of the scheme would fall on the Military.

14. The Government has helped several municipalities with a moiety of the cost of water-supply schemes. But in view of the large amount of the estimate and financial difficulties, it would be over-sanguine on the part of the municipality to expect a grant of more than 3 lakhs.

15. The municipality will therefore have to provide Rs. 3,50,000. Presuming that the whole of this amount would be borrowed from Government, it will involve an annual charge of Rs. 21,000.

16. If the barracks and native lines were excluded from the scheme, it would be possible to reduce the lift by about 30 feet, because Cowl Bazaar and Brucepet which constitute the whole of the municipality are lower than the general level of the cantonment.

17. The inclusion of the cantonment or rather the barracks and native lines in the scheme, compels the whole of the town supply being lifted 30 feet higher than the requirements of the town demand it. The cost of lifting the town supply 30 feet higher would therefore be a legitimate charge on the military. This charge works out to about Rs. 5,000 annually.

18. The balance of the pumping charges would be borne by the municipality and the military in the proportion of the population. The military share of the pumping charges would thus be Rs. $5,000 + \frac{6,000}{66,000} \times (\text{Rs. } 48,000 - 5,000) =$ say Rs. 9,000, and the municipality will have to bear Rs. $(48,000 - 9,000) = 39,000$.

19. The cost of the scheme to the municipality stands thus:—

	Rs.
Interest and sinking fund at 6 per cent. on Rs. 3,50,000	21,000
Pumping charges	39,000
Total ...	60,000

20. *Financial aspect.*—The amount collected as house tax at the maximum rate of $7\frac{1}{2}$ per cent. is about Rs. 28,000 yearly. This includes tax on private houses in the cantonment. An 8-per cent. water-tax which will be the maximum leviable when the new District Municipal Act is passed, would be about Rs. 30,000. This sum could be increased to some extent by the revision of taxes, but it seems doubtful if the municipality would be able to provide Rs. 58,000 annually even with its best efforts.

Order—Mis. No. 1936 M., dated 22nd November 1895.

Communicated to the Sanitary Engineer with the request that the investigation of the Copper Mountain scheme, for which an allotment of Rs. 2,000 was sanctioned in G.O., No. 1469 M., dated 9th September 1895, may be expedited and the result reported to Government at an early date.

(True Extract.)

(Signed) J. F. PRICE,
Chief Secretary.

To the Sanitary Engineer.

Copy to the Chairman, Municipal Council, Bellary,
through the Collector.

G.O., Mis. No. 1010 M., dated 15th June 1896.

Abstract.—Communicating to the Sanitary Engineer and the Municipal Council, Bellary, letter from the Government of India declining to consider the question of pipe-water supply for the town and cantonment of Bellary until a definite scheme has been laid before them.

Read—also the following papers:—

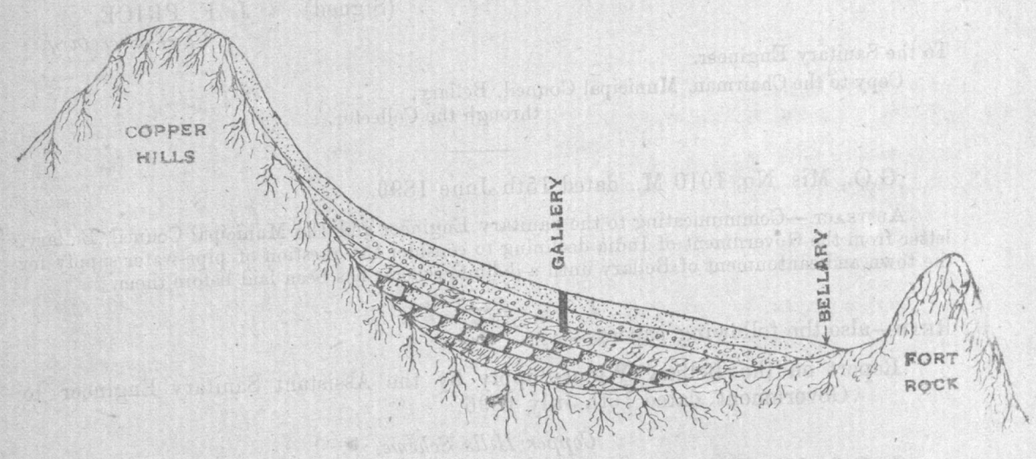
Report on the Bellary Water-Supply by the Assistant Sanitary Engineer to Government, dated 16th July 1896.

Copper Hills Scheme.

In G.O., Mis. No. 1469 M., dated 9th September 1895, Government sanctioned the execution of certain experiments in connection with the Copper Hills scheme. This report deals with the experiments made, and the proposals based on them.

2. I think it necessary to preface this report with a few general remarks in answer to doubts, that have been expressed in certain quarters, as to the possibility of finding any copious and permanent supply of water anywhere between Bellary and the Copper Hills. It has often been asserted that it is futile to look for water in any large quantities in rocky ground. This is a popular fallacy. Certainly, nobody would ever think of finding water in a compact mass of rock, such as the Bellary Fort Rock; but it is a fact well known to every student of Geology and every practical observer, that rocks under certain conditions contain almost as much water as sand and loose gravel. Arenacious rocks, such as sand stones, conglomerate of lime nodules and lime stones, contain a large quantity of water, retained both by saturation and by storage in natural cracks and fissures. The section of the trial trench (*vide* paragraph 9) shows that the structure of the soil is of the above nature.

3. Bellary has always been regarded as a dry place. This is, quite naturally, the first impression of the new comer, as the cantonment stands high and dry; and even Cowl Bazaar and Brucepet, which form the bulk of the town, stand on ground with a sub-stratum of gneiss within a moderate depth of the surface, the outcrop of which is the Bellary Fort Rock. But old inhabitants of Brucepet and Cowl Bazaar say, their wells have never failed even in very bad years. When there is a cry of scarcity of water in Bellary, it does not imply that the wells in the town have run dry, but it implies that the Fort ditch and the Mainwarring tank—the principal sources of supply—have failed; for though the town wells have always been capable of yielding water, they are not used by the people owing to the unwholesomeness of water in them. In corroboration of the above facts, the following extract from Mr. J. W. Martin's (then Superintending Engineer, III Circle) letter No. 570, dated 17th May 1892, embodied in G.O., Mis. No. 1150 M., dated 2nd July 1892, may be cited: "I think I should mention that at present the wells in and around the town are all well supplied. I believe there is no record that they have ever been dry, and in my opinion, taking into consideration the formation of the country, it is most improbable they will ever become dry." It must be remembered that Mr. Martin wrote this in a hot season immediately succeeding a year the rainfall of which is the lowest on record in the past ten years. If even in such a dry year underground water was available in the town of Bellary, where the sub-stratum of compact rock is close to the surface, it follows that water must be available in greater abundance at some distance from the town in the direction of the Copper Hills, because midway between the Fort rock and the hills the gneissic bed lies a long way below the surface.



4. Coupled with the above, there is also the fact that, in Mr. Puttia Chetti's well, which is on the line of the proposed gallery, the level of water has fluctuated within very small limits from season to season and from year to year. My informants were Mr. Puttia Chetti himself and his gardeners. Mr. Puttia Chetti's personal knowledge of the well is short, but the gardeners have known the well and the locality from their infancy. They say that the variation between the waterlevel in the dry and wet seasons in ordinary years is about a foot. Only in 1891—the year which gives the smallest record of rainfall in the past ten years—the level fell by 3 feet.

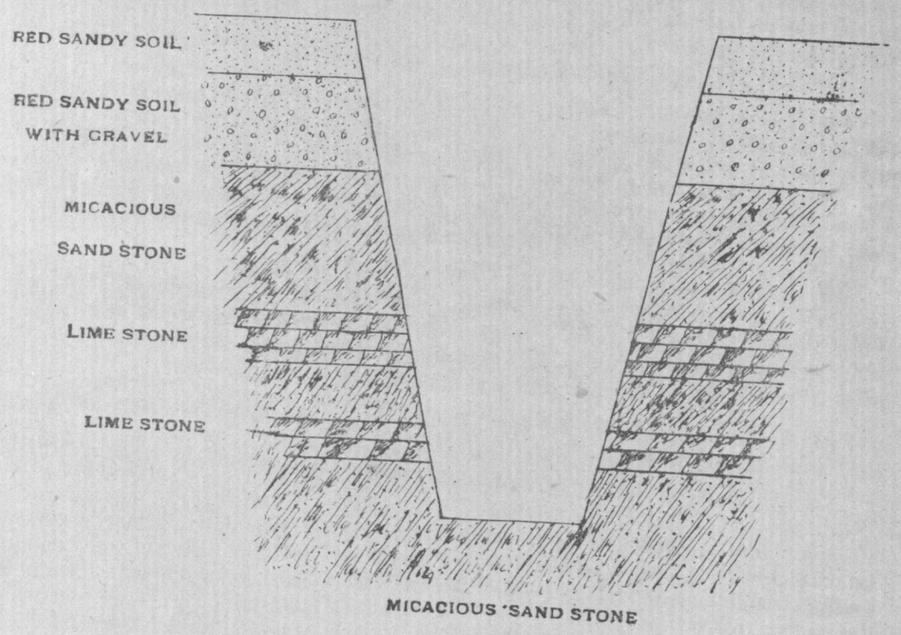
5. The facts and opinions here adduced go to prove the existence of underground water in the country immediately surrounding Bellary, and also that the water is more or less of a permanent character, and for all practical purposes independent of the season or the annual rainfall. The variation between the minimum and maximum annual rainfall at Bellary is so great, that it may be permitted to some to doubt the statement of permanency of waterlevel. But the fact is that the effect of one wet season on underground water does not disappear altogether for the next two seasons, and it seldom or never happens that two or three dry years succeed one another. Thus the natural storage of water underground, under the conditions prevailing at Bellary, is of the nature of a compensating reservoir, which tends to equalize the quantity and level of the underground water notwithstanding great differences in rainfall.

6. The water from the trial trench has been analysed. A copy of the analysis is attached. There is no reason to believe that the water contains any harmful impurities.

7. As the dry season is the proper time for the experiments, the work was not started until the 25th February 1896. The paucity of labour and the demand for coolies for picking cotton, this being the season for it, retarded the works very considerably. The usual resource under similar circumstances, *i.e.*, the importation of foreign labour, could not be adopted, work being of a small magnitude. It was necessary to close the works before the south-west monsoon was well advanced, and it was found impracticable to sink the whole trench to the full depth within the prescribed time. The results achieved are, however, quite sufficient for the purpose for which the experiment was made.

8. The work consists of a trench at right angles to the Billagalu vunka, at a point about a mile and a half from the municipal boundary of Bellary (drawing No. 1). The trench, as executed, is 150 feet long with an average bottom breadth of 12 feet. The 50 feet length, immediately next the river, is 14½ feet deep. The further 100 feet is 18 feet deep, and at the furthest end a pit is sunk reaching a depth of 27 feet (drawing No. 2).

9. The section of the trench, with reference to the structure of the soil, is at its deepest part somewhat as below :—



10. The results of the experiments summarised are as below :—

	Gls. per Minute.
Section A of trench 48′ × 14·1′ and 14½′ deep yielded	30
Section B of trench 83′ and 18′ deep yielded	15
Section C of trench [illegible] × 10′ and 27′ deep yielded	20
Total yield ...	65

11. Section A is nearer the stream and this accounts for its greater yield notwithstanding that its length is less than that of section B. On the other hand section C, which is furthest from the river, yielded in proportion to its length and area more than sections A or B, thus proving the efficacy of the deeper section in regard to the yield of water. This result goes to establish that in the permanent works, should they be constructed, the gallery or trench should be not less than 30 feet deep.

12. Judging by the lie of the various strata underground, the belief is tenable, that the deeper the trench the greater will be the yield of water until compact gneiss is reached. But it is problematical whether the extra cost, both initial and working, of a deeper gallery will be commensurate with the advantage of a greater supply. It will, therefore, be advisable to restrict the depth of the gallery to 30 feet, and make the supply dependent on a longer length rather than on an increased depth (drawing No. 3).

13. The valley to be tapped is about a mile in breadth to the foot of the hill. A gallery about 3,000 feet long is about the greatest length required to intercept practically the whole of the flow from the valley (drawing No. 3).

14. It is not possible to deduce, from the results of the experiments, a formula which will enable, with any pretence to accuracy, the computation of the yield from a longer length of trench or gallery. Calculations based on formulæ deduced from trials even in a homogeneous soil-like sand have led to most unsatisfactory results. In the present instance so much depends upon the porosity of the rock and the crevices and fissures in them, the nature and extent of which may vary with every foot of the trench, that no formula can be framed which would give results even with an approximation to the truth. The estimate of yield, under these circumstances, must only be a matter of judgment based on experience and knowledge.

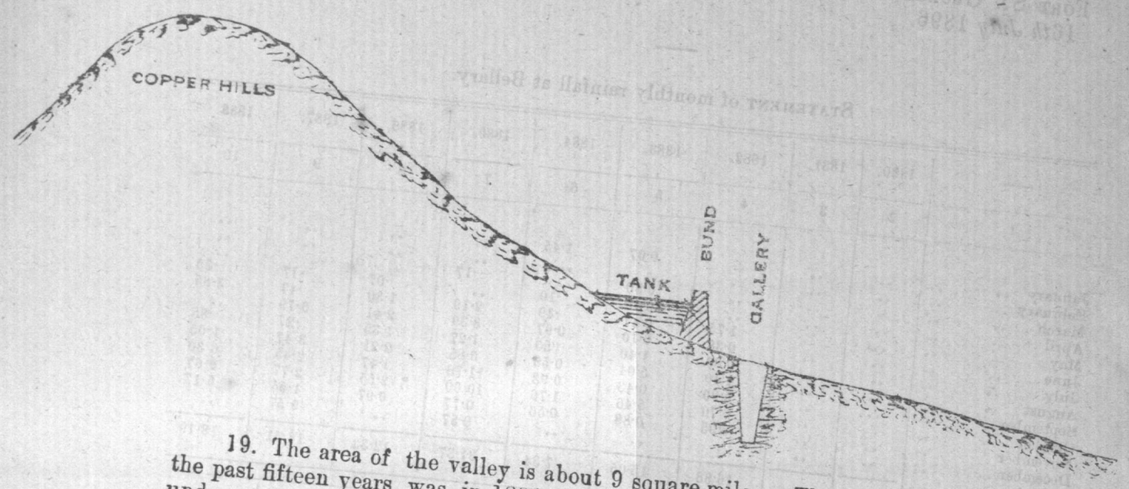
15. It may, however, be safely said that the valley should be capable of yielding 300,000 gallons daily even in a very dry year. In an average year about 600,000 gallons may be expected; but as the efficiency of a scheme is determined by the minimum yield, it is correct to say that this scheme will provide only 300,000 gallons. A consideration of the following facts and deducements will show that the expected yield has by no means been over-estimated, and if it errs it errs on the side of safety.

16. From a trial trench 150 feet long, about 80,000 gallons have been obtained daily. For the permanent works a trench 3,000 feet long is proposed, and the estimated yield is 300,000 gallons. Thus, while the actual yield has been 533 gallons per foot length of the trench, for the purpose of the estimate only a yield of 100 gallons per foot length of the trench has been assumed.

17. Further, the trial trench has only an average depth of 18 feet. It is proposed that the permanent gallery, should be 30 feet deep. An examination of the results of the trial shows the very marked increase in the yield at the depth of 27 feet.

18. I also propose that a bund (drawing No. 3) should be thrown across the valley above the trench or gallery, so that every inch of rain that falls in the valley would be stored either underground or in the tank formed by the bund.

weather, as the underground supply becomes diminished by pumping, it will be replenished by percolation from the tank. The top soil is gravelly and favourable for this purpose.



19. The area of the valley is about 9 square miles. The lowest rainfall within the past fifteen years was in 1884 when it was 7·34 inches. Of the water stored underground and in the tank, 50 per cent. would be available, the other 50 per cent. being allowed for loss by evaporation, &c., or say 3½ inches would be available. 3½ inches over an area of 9 square miles give 73 millions cubic feet. The town supply at 300,000 gallons per day amounts to less than 18 millions cubic feet per year.

20. It is well to state here, that the present year is far from being a typical dry year in Bellary. During the past five years the rainfall has been above the average, and last year the number of inches that fell stood at a figure, the highest but one in the past fifteen years (*vide* table of rainfall appended). Sufficient allowance has, however, been made for this in fixing the yield.

21. A supply of 300,000 gallons per diem will give only a little more than 5 gallons per head of the population. This supply is insufficient. The Sanitary Commissioner has suggested the combination of this supply with that of the Alipore tank. With the two schemes combined, the cantonment will get a supply of 15 gallons per head, and the town 10 gallons per head. The standard fixed for this Presidency is 15 gallons per head per diem. Though it should be the aim of every scheme to secure this quantity, circumstances do not often admit of it. With regard to Bellary it is well nigh a case of choice between half a loaf or starvation. Even with the prospects of a larger supply from the Hagari, the Collector of Bellary considered 10 gallons per head sufficient, or at any rate all that was possible.

22. The Copper Hills supply will cost, exclusive of distribution works:

	Rs.
Bund	35,000
Gallery	50,000
Engine-house	Rs. 10,000
Drivers' quarters	4,000
Store-shed	1,000
Land and fencing	1,000
Engines and pumps	16,000
Reservoir	20,000
Main pipes and valves	15,000
Laying and jointing	70,000
	14,000
Total ...	2,20,000

23. The best mode of combining the two supplies could be considered hereafter when working out the details of the scheme.

Fort St. George,
16*th July* 1896.

(Signed) HORMUSJI NOWROJI,
Asst. Sanitary Engineer to Government.

Statement of monthly rainfall at Bellary.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
1	2	3	4	5	6	7	8	9	10
January	..	..	..	0·07	1·45	..	..	..	..
February	..	..	..	..	..	..	..	..	..
March	..	..	..	0·80	..	·17	..	..	..
April	..	..	..	0·40	·10	..	·07	·17	·30
May	..	..	1·75	0·47	·49	2·19	1·30	·47	3·85
June	..	..	0·38	0·10	0·97	3·39	2·41	6·79	..
July	..	..	0·80	1·40	·50	1·27	1 35	·27	·85
August	..	..	1·40	5·04	0·58	0·85	2·21	3·47	1·05
September	..	..	5·90	0·43	0·93	11·76	1·47	2·45	6·30
October	..	..	0·70	5·46	1·76	10·60	2·55	2·77	0·67
November	..	..	5·95	0·88	0·56	0·77	0 97	1·55	5·17
December	..	..	..	..	..	0·37	..	0·57	..
Total ..	..	..	16·88	15·05	7·34	31·37	12·33	18·51	18·19

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
	11	12	13	14	15	16	17	18
January	..	..	..	..	..	..	..	..
February	..	..	..	..	0·03	..	..	..
March	..	..	0·32	..	1·35	..	..	..
April	1·40	1·70	..	..	0·16	0·43	2·66	0·34
May	·93	1·42	2·39	0·46	0·56	3·66	2·91	6·03
June	·92	·75	2·23	5·40	3·08	0·81	2·31	0·83
July	1·86	1·05	0·52	1·12	4·97	1·09	1·94	..
August	1·20	0·97	1·37	6·45	4·04	3·74	1·83	..
September	11·63	6·20	0·30	3·46	1·28	1·40	7·80	..
October	8·90	6·16	1·00	5·54	6·40	6·58	7·79	..
November	0·60	5·50	0·65	0·25	1.26	2·09	2·09	..
December	..	..	..	..	..	0·13	..	..
Total ..	27·44	23·75	8·78	22·68	23·13	19·93	29·33	..

	Trial well near Copper Mountains, Bellary. I	Sample sent by the Chairman, Municipal Council, Bellary. II
Total solids—Grms. per litre	0·710	0·730
Volatile solids—Grms. per litre	0·070	0·090
Chlorine— Do. per litre	0·134	0·142
Total hardness—Clark's scale	8°·400	8°·050
Permanent hardness—Clark's scale	1°·400	1°·050
Free ammonia—Mlgrms. per litre	trace	0·128
Albumenoid ammonia—Mlgrms. per litre	0·032	0·036
Nitric acid, Nilgrains per litre (as ammonia)	2·550	1·650

Apparent quality of the water as inferred from the results obtained on examination.

Remarks.—The two samples are alike in all respects with two very important exceptions, viz., the variations in the "free ammonia" and in the "nitric acid." The same conditions of purity have evidently not been in existence when the two samples were drawn. In sample I the increase in nitric acid and the trace of free ammonia point to organic matter having become oxidised, while in sample II the subsequent access of fresh organic matter is indicated by the very marked rise in the free ammonia, accompanied by decrease in the nitric acid. The chlorine indication in both strengthens the suspicion that dangerous organic matter finds its way into the water. The results indicate the advisability of searching for and excluding such source of contamination.

NOTE ON THE ANALYSIS OF WATER.

Chemical Examiner's No. 681, *dated 8th July* 1896.

Sample marked II was also drawn from the trial trench, but about ten days after the work was closed. Coolies were working in the trench after the final pumping; and after the close of the work people must have had a free access to the trench. A large number of the inhabitants used to come to the work daily even when it was in progress. The impurities in II were anticipated (*vide* Sanitary Engineer's letter No. 1941, dated 22nd June 1896, to the Chemical Examiner, Madras.) Analysis I must therefore be judged by itself, independent of any considerations involved by analysis II.

Barring the chlorine and the nitric acid the water is such as may be classed as "good." The water is so highly pure with reference to the "free ammonia" and the "albumenoid ammonia" that it indicates that the chlorine and the nitric acid are of mineral origin and not organic origin and therefore harmless (*vide* McNally's Hand Book of Sanitation).

(Signed) HORMUSJI NOWROJI,
Asst. Sanitary Engineer to Government.

From J. A. JONES, Esq., MEM. INST. C.E., F.R.S.E., Sanitary Engineer to Government, to the Chemical Examiner, Madras, dated Fort St. George, 22nd June 1896, No. 1941.

Referring to your letter No. 553 of 3rd June 1896, I have the honour to forward eight bottles of water from a trial well near the Copper Mountains, Bellary, which I request you will be good enough to analyse as soon as other similar engagements will permit you which, I understand, will be about the 29th instant.

2. I am aware that the water should be examined as soon after being drawn as possible, but as the works were closed on the 19th instant, I would not have had another opportunity of collecting the sample in a state of purity and under conditions such as would obtain in the scheme for water-supply.

3. Another sample will, however, be drawn on or about the 27th instant so as to reach you about the 29th instant, and I request that both samples may be analysed at the same time and compared.

BELLARY WATER-SUPPLY.

Office-note by the Sanitary Engineer.

The experiments with reference to the Copper Hills having been now completed, it becomes the duty of the Sanitary Board to place some resolution before Government which will allow of an early decision being come to as to what scheme or what combination of schemes should be adopted so that the design therefor put in hand. The Government of India (*vide* letter of Director-General of Military Works accompanying) is desirous that some scheme should be decided on and carried out at an early date, and this note is circulated to the Board not in order that the details of any scheme be criticised but rather that the Board should recommend to Government which of the following schemes, if any, should be accepted.

2. There are now three schemes, viz.—

(1) The Hagari River Scheme.
(2) „ Copper Hills „
(3) „ Alipore Tank „

For convenience I take the Hagari scheme as first in order. The report on the Hagari scheme was sent to the Collector of Bellary and through him apparently it reached the Director-General of Military Works. The cost of this scheme is estimated

at Rs. 7,50,000, but I am not at all sure that when the scheme is worked out in detail it will be possible to limit the cost to any such amount. The scheme is a 10-gallon scheme except the pumping main, the size of which is estimated for 15 gallons. The financial one is not the only objection to the cost of this scheme. The Sanitary Commissioner has placed on record as far as I remember that this scheme should be looked on only as a last resource as the waters of the Hagari are far from chemically pure and unsuitable for drinking purposes. I may leave this point to be noted on by the Sanitary Commissioner who has made a sanitary survey of the river at the proposed offtake. As I hope to show further on, there is no advantage in the adoption of this scheme. The next scheme is the Copper Hills scheme. A full report on the experiments, &c., in regard to this scheme is attached. The Assistant Sanitary Engineer does not consider that it can safely be assumed that more than 300,000 gallons per diem can be obtained from this scheme. This is based on what is considered a low estimate from the results of the experiments made, but the experiment was for a very short period, the trench short in comparison to what would have to be constructed and it is therefore very difficult if not impossible to say what would be got from a gallery 3,000 feet long. The amount of water to be obtained would decrease, I think, very rapidly the further the gallery extends from the centre of the valley.

3. I do not therefore feel at all assured that even 300,000 gallons or 5 gallons per head could be obtained.

4. The estimate, Rs. 2,20,000 (exclusive of distribution work Rs. 1,20,000 * or a total of Rs. 3,70,000†) is, I think, also low; the gallery should be constructed above the bund and could not be merely filled with gravel as is proposed. A built gallery would add tremendously to the cost.

* This is for a 5-gallon supply and pumping from near the reservoir.
† Includes contingencies.

5. The scheme, however, might be considered as a supplemental scheme which could be constructed should scheme No. 3, which I shall presently describe, fail to deliver the required supply, and in such case the water from the Copper Hills scheme might either be pumped direct into the town or preferably into the service reservoir at A (see tracing). The routes of such pipe lines are marked on tracing accompanying.

6. I now come to the Alipore scheme; this scheme is fully described in a note by Mr. Walch, who was Chief Engineer at the time. His note is attached. My original report and all other papers are in the file forwarded herewith.

7. With reference to paragraph 8 of that note I have gone very carefully over the calculation of the inflow and outflow of the tank, and seeing that it was not likely that 15 gallons per head could be supplied, I have adopted a supply of 10 gallons per head and the evaporation of 7 feet per annum as assumed by Mr. Walch. The inflow and outflow of the tank raised 5 feet (but not extended as originally proposed) has been carefully plotted according to Rippl's method and the mass curve derived therefrom shows that even at the end of the very bad years referred to by Mr. Walch, viz., 1883 and 1884 there would still be in the tank a balance of 2·46 million cubic feet and this under the unfavourable condition of taking the tank empty at the beginning of the year 1880.

8. Mr. Walch has omitted to take into consideration the surpluses which would run to waste and of course we are now dealing with a supply of 10 gallons per head instead of 15 gallons.

9. Under the system adopted of continuous ploting of the demand and supply curves and their results, there can be no doubt that the tank, if raised, will supply Bellary with 10 gallons per head. The present tank can contain only 102 millions cubic feet with an area of 242 acres at F.T.L., while the raised tank would hold 152 millions cubic feet with 370 acres area at same level.

10. It is not a question of the benefit to be derived from the increase in capacity in the three dry years but the benefit derived during those years from the surplus amount remaining in the tank at the beginning of dry years.

11. I need not further dilate on this point, the diagrams forwarded herewith show absolutely what would have been the state of matters between 1880 and 1891 or for 12 years (including the three driest years) at which latter date the scheme was framed. Mr. Walch, it may be said, accepts the figures of the absolute supply from the areas included by the new channels.

12. The scheme as originally designed was estimated at, including establishment, Rs. 9,06,642, but if the tank be raised and not extended and other reductions be made for a supply of 10 gallons instead of 15 gallons, the estimate would stand as follows, namely, a total of Rs. 7,15,000, of which Rs. 5,67,121 would be the town share and Rs. 1,47,779 the cantonment :—

Description of works.	Cost.	Town share.	Cantonment share.
	Rs.	Rs.	Rs.
Supply channels, &c.	90,000	77,728	12,272
Raising and strengthening Alipore Tank bund ..	49,000	42,319	6,681
Extending existing sluice	600	518	82
Outlet arrangements at head of sluice	6,000	5,182	818
Engine and Boiler House	20,000	17,273	2,727
Engine Driver's quarters	6,000	5,182	818
Store shed	2,000	1,728	272
Engines, pumps and boilers including erection ..	31,850	27,507	4,343
Service reservoir	40,000	34,546	5,454
Supply and delivery of pipes	3,50,000	2,61,558	88,442
Laying and jointing	65,000	46,570	18,430
Total ..	6,60,450	5,20,111	1,40,339
Contingencies, &c. ..	54,550	47,110	7,440
Grand Total ..	7,15,000	5,67,121	1,47,779

13. If the Government of Madras made, as an exceptional case, a grant of say three lakhs and the Military of one lakh as proposed in addition to the cost of their share, the municipality would have to borrow only Rs. 1,67,121 and their actual annual expenditure would not be more than (including repayment of loan) :—

	Rs.
5·96 per cent. on Rs. 1,67,121	9,960
Annual charges for pumping $\frac{5}{6}\frac{7}{8}$ of 6,025	5,203
Do. for maintenance	9,000
Total ...	24,163

which is well within their powers as it is said Rs. 50,000 annually could be afforded.

14. It is requested that this question may receive early attention as the Government of India is anxious for some scheme to be carried out at an early date.

Fort St. George,
29*th July* 1896.

(Signed) J. A. JONES,
Sanitary Engineer to Government.

From Surgeon-Lieut.-Colonel W. G. KING, M.B., C.M., D.PH., Sanitary Commissioner for Madras, to the Collector of Bellary, dated 15th April 1896, No. 808/S.

With reference to your letter No. 1964, dated 4th July 1895, I have the honour to state that I found the river on my inspection on the 17th February 1896, with no visible stream on the surface of the bed, although an active flow was in progress from the sub-stream in the Rupanagudi channel. Above the site from which the specimen of water had been taken, were two large areas of melon cultivation. The sandy bed of the river was found, at frequent intervals, to be covered with layers of whitish salts.

Wherever small depressions had favoured the collection of water and evaporation had followed, these salts were found the more readily. No direct entrance of drainage from any village was at time of my inspection likely, in view of the complete absence of rain for some time previously, and this would seem to correspond with the condition of affairs as found at time of taking the sample in March and May 1895.

2. An examination of the salts on the spot, without the aid of either microscope or chemical analysis, seemed to me to show that they were largely saltpetre. The chemical analysis, however, proves that I was wrong, and that there being but a trace of these salts they consisted "principally of mixed chlorides and sulphates of alkalies and of lime with small amounts of ferric oxide and alumina (nearly 6 per cent.) and nearly 35 per cent. of matter insoluble in hydrochloric acid (sand silica, &c.)." From enquiries made by me, it would seem that much of the surrounding land exhibits the presence of these salts largely, and that certain of the minor streams entering the Hagari are brackish on this account, and further that the sub-soil water as shown by the village wells is also brackish. It may thus be accepted as regards the chlorides that they do not represent previous sewage contamination. The undesirable feature to be accounted for, however, is the persistent and considerable amount of free ammonia in the three analyses. Before accepting this as due to vegetable matter undergoing change during slow passage through the river sand, it would be desirable to eliminate, as a possible cause, the mass of changing vegetable and animal organic matter represented by the melon beds, by securing a specimen of water above them for analysis. Unless these melon beds occur at small intervals up the river course, it would then be possible to pronounce the water as safe from animal contamination—the chief point to be held in mind.

3. Granting that the analysis show no marked improvement at a site higher up than that selected for specimens already examined, the water cannot be regarded as fit for domestic consumption, if delivered without preliminary treatment. This would involve the use of "Anderson's revolvers," and subsequent filtration through ordinary public water works sand filters, after lifting the whole supply from the river bed previous to subsequent forcing to Bellary. Even when thus treated, the water may be subject to much variation in composition, taking into account the fact that the condition of salt patches found on the surface of the sandy bed must be repeated layer after layer in the bed itself, and that on applying pumping in wells sunk in the substream, these salts would from time to time be washed with the inflow.

4. I, therefore, consider before coming to any definite conclusion as to the advisability or otherwise of using Hagari water when compared with other possible schemes such, for example, as uniting Mr. Nowroji's sub-soil water scheme with a rainfall impounding scheme to eke out the full requirements of the town of Bellary that (1) another specimen of the water should be taken from the river at a point well above the melon beds and be sent to the Chemical Examiner for opinion; and (2) that an experiment should be conducted in imitation of treatment by Anderson's revolvers agitation with iron rivet cuttings, &c., and subsequent filtration through sand, with the object of ascertaining what grade of improvement the water would undergo after this treatment.

Office-note by the Sanitary Commissioner, dated 10th August 1896, No. 334-S.B., regarding the Bellary water scheme.

With reference to paragraph 2 of the Sanitary Engineer's note, my views are detailed in the accompanying copy of letter No. 808-S., dated 15th April 1896, addressed to the Collector, Bellary.

2. There being no doubt as to the financial capabilities of the municipality (*vide* Sanitary Engineer's note paragraph 13) to support a scheme sufficiently comprehensive to ensure not merely that water shall be supplied to the town, but that also it shall be of a quantity and quality to ensure sanitary results, I consider the scheme that should be adopted is that of uniting the Copper Hill gallery with that for the enlargement of the drainage area of the Alipore Tank.

3. As the Copper Hill supply must be regarded as supplemental to the greater impounding scheme at Alipore, and punctuality of delivery would not be essential so long as ultimate economy of the main tank supply was effected, it is worth while considering whether expenditure would not be saved by trusting to pumping from the gallery to the service reservoir by wind power.

4. Further, in considering the financial possibilities of the scheme, it is advisable to remember that if the supply is to be sanitarily safe that portion collected in Alipore Tank should be subjected to filtration before distribution, as it is obtained from an inhabited area. The Copper Hill supply would not require filtration.

No. 153-S.

Note by the President, Sanitary Board.

Three schemes have been proposed for the water-supply of Bellary, viz. —

1. The Hagari River scheme.
2. „ Copper Hills „
3. „ Alipore Tank „

2. The principal points to be considered in connection with these schemes are—

1. The quantity of water available.
2. „ quality of the water.
3. „ cost both for construction and upkeep.

3. The population of Bellary is about 66,000 and the supply required at 15 gallons per head per diem is 990,000 gallons per day or 687 gallons per minute.

4. *Hagari scheme.*—The information given regarding the quantity of water available in the Hagari is not very complete. It is stated in the Sanitary Engineer's report, dated 19th February 1895, that owing to certain facts, there is very little doubt about the sufficiency of the supply, and I agree with this opinion and think there is no doubt that the supply will be ample. As regards the quality of the water, it is stated that the popular idea is that it is good, but the Sanitary Commissioner is of opinion that the water is not fit for domestic purposes without preliminary treatment; but I think that as the water is to be collected in an infiltration gallery pumped up 235 feet through 8 miles of piping into a service reservoir and then distributed through a further length of piping, the preliminary treatment may be dispensed with, but if it is found necessary, filters may be added. As regards the cost, the estimate has been worked out for a supply of 10 gallons per head per diem though the 8 miles main has been made large enough to supply 15 gallons per head. The main, which is the most expensive item in the estimate, has been made thick enough to withstand a head of 300 feet throughout, this is unnecessary and a reduction may be effected which would go to cover the extra cost of engines. The estimate for the 10 gallons supply amounts to Rs. 7,50,000 and it is probable that a 15 gallons supply could be provided for Rs. 8,00,000.

If the Government contribute three lakhs towards the project and the Military department one lakh, the amount to be provided by the municipality will be four lakhs which represents an annual charge of Rs. 16,000.

The cost of pumping 15 gallons would be—

$$\frac{66{,}000 \times 15 \times 340 \times 365 \times 10}{1{,}000{,}000 \times 16} = \text{Rs. } 63{,}200 \text{ in round figures to which}$$

must be added Rs. 5,000 for establishment and repairs making a total of, say, Rupees 69,000.

Towards this sum the Military department will pay Rs. 10,000, therefore the cost to the municipality will be Rs. 59,000.

The annual charge to municipality will therefore be—

	Rs.
Interest on 4 lakhs	16,000
Working expenses	59,000
Sinking fund at 2 per cent.	8,000
Total	83,000

The cost of this scheme will therefore be—

	Rs.
Construction	8,00,000 * about.
Upkeep	83,000 per annum.

Copper Hills Scheme.—The quantity of water available is exceedingly doubtful as is always the case in subterranean sources, the fact that a copious supply of water has been found at one spot, such as Mr. Puttia Chetty's well, does not make it certain that a good supply will be found in the rest of the valley as a "fault" may divert the water elsewhere, although geological knowledge of the whole area from which the water is to be obtained is necessary and even then the yield is doubtful. The Assistant Sanitary Engineer has assumed that a supply of 300,000 gallons, or 5 gallons per head per diem, can be obtained, but the estimate is framed on experiments carried on for a very short period: he states that the area of the valley is 9 square miles and that if 50 per cent. of the lowest rainfall, viz., 7·34 inches be assumed to be stored below ground, the yield would be 73 millions cubic feet; the yield reckoned on by him being less than 18 millions cubic feet. Fanning, in his book on Water-supply, states that in a district where the mean annual rainfall is 40 inches, the percolation into one square mile of porous soil in dry years is 12·5 millions cubic feet per annum and that for the quantity received into well or springs in that area it would seldom be safe to take more than from 10 to 20 per cent. or, say, 1·5 million cubic feet, so the yield from the 9 square miles of the Copper Mountain valley would only be 13·5 million cubic feet, but the mean annual rainfall in Bellary is only about 18 inches so that probably not more than 5 or 6 millions cubic feet could be obtained in a year of drought.

The quality of the water is apparently good and will require no preliminary treatment.

The cost of the scheme will be Rs. 3,70,000, the working expenses about Rupees 23,000.

Alipore Tank Scheme—Quantity.—According to the Sanitary Engineer the tank, if enlarged, would hold sufficient for a supply of 10 gallons per head, and the run-off from the catchment will be sufficient to fill the tank with the increased capacity. The accuracy of this of course depends on the assumed run-off, and Mr. Jones has apparently taken Nagpore as an example, but I consider that the supply is doubtful.

Quality.—I can find nothing in the papers regarding the quality of the water.

Cost.—Mr. Jones estimates the cost at Rs. 7,15,000, if out of this sum Government provides Rs. 3,00,000 and the Military Department Rs. 1,00,000, the sum to be provided by the municipality will be Rs. 3,15,000:—

	Rs.
Interest on Rs. 3,15,000 at 4 per cent.	12,600
Sinking fund at 2 per cent.	6,300
Charge for pumping	5,203 †
Do. for maintenance	9,000
	33,103

say, Rs. 33,000. This figure differs from Mr. Jones, as I cannot find anything in the papers to show that the Military Department will pay one lakh of rupees in addition to their share, so I have taken the contribution for it to be only one lakh as in the case of the Hagari scheme.

* If, however, a 10-gallon scheme is adopted, the initial cost will be about Rs. 7,00,000 and the working expenses to be borne by the municipality Rs. 55,000.

† See Mr. Jones' figures.

In his note, dated 10th August 1896, the Sanitary Commissioner advocates a combined Alipore tank and Copper Mountains scheme. Now the cost of the former is Rs. 7,15,000 and of the latter Rs. 3,70,000, total Rs. 10,85,000, supposing Government and Military Department to provide four lakhs between them, the interest and Sinking fund at 6 per cent. on the balance, viz., Rs. 6,85,000, will be Rs. 41,100. The pumping expenses from the tank alone are Rs. 5,203 and double pumping would, I presume, be required, so that the working expenses would not fall short of Rupees 60,000, and for this expenditure a supply of not much over 10 gallons a head would be obtained.

To sum up we have—

Hagari Scheme.—Quantity, ample for 15 gallons or more. Quality, good on delivery—

	Rs.
Capital cost	7,00,000 *
Working expenses	55,000 *

Copper Mountain Scheme.—Quantity, altogether insufficient. Quality, good—

	Rs.
Capital cost	3,70,000
Working expenses	23,000

Alipore Tank Scheme.—Quantity, doubtful. Quality, not known—

	Rs.
Capital cost	7,15,000
Working expenses	33,000

Combined Alipore Tank and Copper Mountain Scheme.—Quantity, sufficient for 10 gallons supply. Quality, not known—

	Rs.
Capital cost	10,85,000
Working expenses	60,000

The capital cost given in each case is total cost, while the working expenses are only those to be borne by the municipality.

After carefully considering all the schemes I am of opinion that the Hagari river—one giving a supply of 10 gallons a head—is the best; it possesses the advantage of having a certain supply and being able to increase that supply to 15 gallons a head, should that be found necessary hereafter and none of the other schemes possess these advantages, I therefore consider that the Hagari scheme should be worked out in detail.

(Signed) D. McNEIL CAMPBELL, Colonel, R.E.,
President, Sanitary Board

To the Sanitary Engineer,
with papers, in original, returned.

Note by the Sanitary Engineer to Government.

[*Reference.*—Note by the President, Sanitary Board, No. 153-S., dated 2nd October 1896.]

The Hagari Scheme.—The estimate of Rs. 7,50,000 for this scheme in the report, dated 19th February 1895, must be considered only as an approximate estimate, though it was as near an approximation as possible with the information then available. Since then survey and levels have been taken for the Hagari scheme and the proper site for the head works has been located. It is now found that the actual lift, exclusive of frictional head in the pipes, is 240 feet against 235, and that the actual length of the main will be 50,000 feet instead of 42,080 feet (8 miles) assumed originally. The original length was measured off a plan, 1 inch = 1 mile.

* At 10 gallons a head.

2. The size proposed for the pumping main is 12 inches, which requires a hydraulic grade of 2 in 1,000 to deliver 687 gallons per minute (15 gallons supply). The head required in a length of 50,000 feet will be 100 feet and the total lift will therefore be 240 + 100 = 340 feet. In the President's note an error has crept in by assuming for the 15 gallons scheme the same lift as in the 10 gallons scheme. The total lift in the 10 gallons scheme will now be 285 feet.

3. The thickness of the main should of course be calculated for a 15 gallons supply as eventually it is expected to carry this quantity. The following table gives the thickness of pipes (and weight) necessary for various heads in a 12-inch pipe (see Fanning):—

Head.	116 Feet.	230 Feet.	300 Feet.	340 Feet.
Thickness *	$\frac{9}{16}$″	$\frac{5}{8}$″	$\frac{11}{16}$″	$\frac{3}{4}$″
Average weight per foot .. cwt.	·69	·76	·83	·90

By plotting the hydraulic gradient of the pumping main, it is found that the pipe should have the following thickness for the lengths noted opposite to them:—

For 9,000 feet,	$\frac{9}{16}$″.
For 21,000 „	$\frac{5}{8}$″.
For 15,000 „	$\frac{11}{16}$″.
For 5,000 „	$\frac{3}{4}$″.
Total ...	50,000 feet.

4. The cost of the main will now be Rs. 2,94,000 in round figures.

The cost of the Hagari scheme, as revised, will now be approximately as follows:—

Description of work.	Fifteen gallons supply.	Ten gallons supply.
	Rs.	Rs.
Infiltration works	50,000	50,000
Engine house, drivers' quarters, store-shed, land, fencing, &c.	50,000	50,000
Engines and pumps	96,000	75,000
50,000 feet of 12-inch pumping main pipes	2,94,000	2,94,000
Service † reservoir	75,000	50,000
Distribution system	2,15,000	2,15,000
Total ...	7,80,000	7,34,000
Contingencies	70,000	66,000
Grand Total ...	8,50,000	8,00,000

It is assumed that the Government is prepared to contribute at least 3 lakhs towards any scheme for the water-supply of Bellary, and if the Military Department make a grant of 1 lakh, the municipality will have to provide 4·5 lakhs in the 15 gallons scheme and 4 lakhs in the 10 gallons scheme which represents Rs. 27,000 and Rs. 24,000 annually for interest and Sinking fund.

5. The pumping charges will be for the 15 gallons scheme—

$$\frac{66,000 \times 15 \times 340 \times 10 \times 365}{1,000,000 \times 16} = \text{Rs. } 77,000 \text{ in round figures.}$$

In the 10 gallons scheme the pumping charges will be—

$$\frac{66,000 \times 10 \times 285 \times 10 \times}{1,000,000 \times 16} = \text{Rs. } 43,000.$$

* No reduction is possible in the thickness given. They are thicknesses from actual calculations. In American practice much greater thickness is given in direct pumping schemes. For instance, Fanning gives a case where a 12-inch pipe, $\frac{1}{8}$ inches, has been used for only a head of 260 feet.

† The service reservoirs provided in estimate are of 1½ days' capacity. A three days' storage is advisable in this scheme considering that the main is over 9 miles in length under a maximum pressure of 340 feet.

The total cost to the municipality on the assumption that Military Department will pay Rs. 10,000 towards pumping charges will be—

	Ten gallons scheme.	Fifteen gallons scheme.
	Rs.	Rs.
Interest and Sinking fund	24,000	27,000
Pumping charges	33,000	67,000
Maintenance of pipes, &c.	5,000	5,000
Total ...	62,000	99,000

6. In the estimates for the Hagari scheme no provision is made for the military distribution system. The cost of this, *i.e.*, about Rs. 1,70,000 (*vide* letter from the Director-General of Military Works, No. 1034 B., dated 16th April 1896), the Military Department is prepared to incur in addition to the contribution of 1 lakh towards the general scheme. The Hagari scheme will therefore cost the Military Department an initial outlay of Rs. 2,70,000 and an annual expenditure of Rs. 10,000 pumping, *plus* Rs. 2,000 maintenance of pipes in cantonment.

7. *Copper Hills Scheme.*—The work proposed is a continuous trench across the valley, and under such circumstances, according to Fanning, it should be possible to obtain 50 per cent. of the quantity of water absorbed or, say, 3 millions cubic feet per square mile, which equals to about 27 millions cubic feet for the whole drainage area, while the yearly yield reckoned at 300,000 gallons per day amounts to only 18 millions cubic feet. Again a factor of no little importance which has to be reckoned in calculating the yield is the tank which the scheme provides at the gallery, which will hold about 74 millions cubic feet. The tank will retain the greater portion of the rainfall which at present drains off the area and in dry weather it will feed the underground springs.

8. The cost of the scheme, including distribution independent of any other scheme, will be Rs. 3,70,000 (*vide* Sanitary Engineer's and Chief Engineer's notes).

9. The pumping charges will be $\frac{300,000 \times 365 \times 40 \text{ (lift)} \times 10}{1,000,000 \times 16} = \text{Rs. } 2,800.$

Assuming that Government will contribute a moiety of the cost, the annual cost to the municipality will be—

	Rs.
Interest and Sinking fund on Rs. 1,85,000	11,100
Pumping charges	2,800
Maintenance of pipes	3,100
Total ...	17,000

It is not apparent how the figure of Rs. 23,000 in the President's note was arrived at.

10. The estimate of Rs. 3,70,000 includes cost of distribution pipes in the town of Bellary (exclusive of the cantonment) for a delivery of 10 gallons per head. If combined with the Alipore scheme, the cost of the supply from the Copper Hills will be only Rs. 2,20,000 instead of Rs. 3,70,000, as the Sanitary Engineer's estimate in his note on the Alipore scheme includes complete distribution in the town and cantonment for a 15 gallons scheme.

11. *Alipore Tank Scheme.*—The question as regards the quality of the water in the Alipore tank has never been raised before, though the scheme has been under consideration for years past. The water has always been considered good. There is no doubt that it is so and far superior to the Hagari water.

12. In calculating the cost of this scheme to the municipality the President takes the contribution from the Military Department as 1 lakh, but in the Sanitary Engineer's memorandum the share of the Military Department is calculated at Rupees 1,47,000. If, however, the Military Department is not prepared to contribute any more than its equitable share of cost, the annual cost to the municipality will be as under—

	Rs.
Interest and Sinking fund on Rs. 2,67,221	16,000
Pumping charges	5,203
Maintenance	9,000
Say	30,000

In this scheme provision is made for pipes in the cantonment but not distribution in barracks. The latter will cost about Rs. 70,000. The cost to the Military Department in the Alipore scheme will be—

	Rs.
Initial cost—	
Contribution towards the general scheme including pipes in cantonment	1,47,000
Additional for distribution in barracks, &c.	70,000
Total ...	2,17,000
Annual cost—	
Pumping	1,000
Maintenance of pipes	2,000
Total ...	3,000

14. *Combined Alipore Tank and Copper Mountain Scheme.*—The cost of this scheme will be—

	Rs.
Alipore tank scheme	7,15,000
Copper Hills scheme	2,20,000
Total ...	9,35,000

The pumping charges will be—

	Rs.
Alipore tank supply	6,025
Copper Hills supply	2,800
Total ...	8,825

The military share of the pumping charges in the combined scheme will be about Rs. 1,000, or Rs. 9,000 less than in the Hagari scheme. Rs. 9,000 capitalised at 3 per cent. represents 3 lakhs. If the Military Department contributes to the municipality Rs. 2·5 lakhs in the case of the combined scheme, the expenditure to them will still be less than in the Hagari scheme.

15. Government will contribute 3 lakhs. The amount the municipality has to provide will in such case be 3·85 lakhs.

16. The cost of the combined scheme to the municipality will be—

	Rs.
Interest and Sinking fund on 3·85 lakhs	23,000
Pumping charges (less 1,000 to military)	7,825
Maintenance	9,000
Say	40,000

17. The cost to the Military Department in the combined scheme will be—

	Rs.
Initial cost—	
Contribution to municipality including pipes in cantonment ...	2,50,000
Distribution within barracks	70,000
Total ...	3,20,000
Annual cost—	
Pumping charges	1,000
Maintenance of pipes	2,000
Total ...	3,000

18. Comparing the Hagari scheme (10 gallons) and the combined Alipore and Copper Hills scheme, the statement as regards the municipality and the Military Department stands thus:—

	Municipality. Rs.	Military Department. Rs.
Annual cost—		
Hagari scheme (10 gallons)	62,000	16,510 *
Combined Alipore and Copper Hills schemes	40,000	12,600 *

19. The undersigned notes that the President states that the quality of water of the Hagari will be good when pumped from wells; there is no ground for this statement and though it may turn out to be so it is doubtful, considering the pollution the Sanitary Commissioner has found which is not one likely to be removed by natural sand filtration. The Sanitary Commissioner is, it is understood, greatly opposed to the use of Hagari water if any other source can be adopted and it is therefore a question whether he is prepared to consider the Hagari scheme at all under the circumstances.

20. The undersigned favours the Alipore scheme supplemented if it is found insufficient by the Copper Hills scheme, especially as it is a cheaper one, and the water is purer, while the Sanitary Engineer himself believes the quantity will be perfectly sufficient.

(Signed) J. JONES,
Sanitary Engineer to Government.

From Surgeon-Lieutenant-Colonel W. G. KING, M.B., C.M., D.PH., Sanitary Commissioner for Madras, to the Collector of Bellary, dated Fort St. George, 25th September 1896, No. 1764/S.

With reference to your endorsement, No. 901, dated 18th September 1896, upon report by the Chemical Examiner of the water from the river Hagari, I have the honour to request you will kindly inform me of the date and site of collection, and will add information as to whether the melon beds referred to in my letter No. 808/S, dated 15th April 1896, existed at time of collection.

Ref. on C. No. 901.

True copy communicated with Sanitary Commissioner's No. 808/S. to the Chairman, Municipal Council, Bellary, for favour of early compliance.

(Signed) J. T. LEVER,
for *Collector.*

1*st October* 1896.

* Including interest on capital charges at 3 per cent.

The day on which the water was collected from the bed of the river Hagari was on the 18th of August last and the site was about 152 yards to the south of the bridge in a line with the 4th pile, there were no melon beds existing at the time of collection. The Tahsildar of Bellary was present at the time when the water was collected.

(Signed) E. FAIRMAN,
Sanitary Inspector, Brucepet.

8*th October* 1896.

Enclosure.

A.

	Irrigation channel water near Rupanagudi.	Spring water taken in the bed of the Hagari river near Rupanagudi.
Total solids, grms per litre	0·670	0·400
Volatile solids, ,, ,, ...	0·120	0·080
Chlorine, ,, ,, ...	0·168	0 060
Total hardness Clark's scale	5°·775	3°·850
Permanent hardness ,, ...	Trace.	Trace.
Free ammonia, milgrms per litre	0·088	0·096
Albuminoid ammonia ,, ,, ...	0·176	0·192
Nitric acid ,, ,, (as ammonia)	Trace.	Trace.
Apparent quality of the water as inferred from the results obtained on examination	Suspicious.	Suspicious.

(Signed) W. G. KING, Surgeon-Lt.-Col.,
Sanitary Commissioner.

B.

	Hagari water.
Total solids, grms per litre	0·230
Volatile solids ,, ,, ...	0·100
Chlorine ,, ,, ...	0·019
Total hardness, Clark's scale	1°·575
Permanent hardness ,, ,, ...	0°·350
Free ammonia, milgrms per litre	Trace.
Albuminoid ammonia ,, ...	0·032
Nitric acid ,, (as ammonia)	0·270

Apparent quality of the water as inferred from the results obtained on examination usable—very much better than the last sample. Examined and reported on in my No. 638, dated 17th June 1895.

The water contained fine river mud, and so it was filtered through ordinary filted paper before examination. As the water will, no doubt, be passed into settling tanks or through filted beds before distribution for supply, the above proceedings does not make any important difference in the estimation of the water for potability.

(Signed) J. L. VAN GEYZEL,
Chemical Examiner.

No. 443-S.B.

Note by the Sanitary Commissioner for Madras.

[*Subject*—Bellary Water-supply.]

[*Reference.*—This office-note, No. 334 S.B., dated 10th August 1896, forwarding copy of this office letter, No. 808 S., dated 15th April 1896.]

I forward, for information, copy of the analysis (*a*) discussed in the above reference, and one since made, (*b*), dated 18th September 1896, but only received by me on the 14th instant.

2. It will be seen that my suggestion that the organic contamination may be due to the melon beds is correct. These beds having ceased to exist probably since June, their influence to the marked extent formerly apparent, is not now exhibited.

So far, the result is satisfactory; but in view of the notorious mawkishness of the water (the municipality, in their address to His Excellency the Governor lately described it as "brackish"), the existence on the bed of the river of large deposits of salts recognized as *sulphates* of the alkalies—a most undesirable form—and the nature of the surrounding land, I consider it would be erroneous to determine to use this source without going to the further test of ascertaining to what extent the quality of the water varies with the season. In my opinion it will be found to be unfavourably influenced after moderate rainfalls. The test now required is that by sinking a well in the river-bed or by boring, it should be ascertained after vigorous pumping for several days, during the early part of the monsoon, how far the salts are brought into solution from the sub-soil and surface. In sinking the well, the nature of the sand as to salt deposits should also be examined.

3. In regard to the President's proposal to trust to purification during transit in pipes, it must be remembered that whilst albuminoid ammonia is thus advantageously affected—giving, however, the consumer an equivalent dose of nitrates — it does not follow that the pipe system of distribution is a safe locality for purification to be effected. As regards salts in solution, neither this nor the passing through the sand of the gallery would ultimately have material effect on the amount. But, by the use of Anderson's revolvers, as suggested by me, both a deprivation of organic constituents and an appreciable benefit in salt constituents would have been obtained before pipe entry. However, this suggestion need not now be discussed, as it was made in the eventuality of the Hagari water proving still "suspicious" *after removal of the melon beds*. If the water gives as good results on the application of the test suggested in paragraph 2 as on the last analysis, (B), it would not be essential to undertake any purification process before distribution.

4. I invite the attention of the President to the result of the first analysis as to organic contaminations at a site about 500 yards below the melon beds and that now obtained, when these were no longer in existence, with the suggestion that it should shake his trust not only in the purification from organic constituents he expected in this instance from so-called filtration through a gallery in a saturated mass of sand of a river-bed, but in reference to similar conditions in the Bezwada supply.

5. As to the Alipore tank-supply, no analysis has been provided. It should have been procured before this stage of the discussion. I, however, fully agree with the Sanitary Engineer to Government that there exist no *primâ facie* grounds why this water should not be of good quality—provided storage is conducted with care. Analysis of the Copper Hill infiltration gallery has already shown this to be good.

Fort St. George,
22*nd October* 1896.

(Signed) W. G. KING, Surgeon-Lt.-Col.,
Sanitary Commissioner.

Note by the President, Sanitary Board.

I am still in favour of the Hagari scheme as giving a more certain supply than the others. I consider certainty of supply is quite as important as the quality of the water, for in the event of a failure, the people would have to fall back on their old disused sources of supply such as wells which would have become foul. Moreover, the latest analysis of the Hagari water shows that it is usable. This analyses differs considerably from the first and their is, no doubt, that analysis taken out at different times of the year would all give different results. I have seen the bottles of water taken from the same part of the same tank and at the same time and the water in each gives a different result when analysed. My opinion that the water would get purer by being pumped up through a considerable length of piping was based on some experiments I had made at Mysore; water that was chemically bad was passed through only a short length (I think about two miles of piping) and was found afterwards to be much purer. The working expenses of the Hagari scheme are, no doubt, very high and if beyond the means of the municipality, the only resource is to carry out the Alipore scheme to be afterwards supplemented, if necessary, by the Copper Mountain scheme.

I am doubtful about the supply from the Alipore tank for in a district with an average rainfall of only 17 inches the run off will be very small, and, in some years, practically nothing and it is hardly safe in such circumstances to trust to impounding reservoirs.

The uncertainty of supply in subterranean schemes is well known and with such a low rainfall the uncertainty is still greater and I think it probable that in years like 1884 and 1891 when the rainfall was only 5·79 inches and 8·46 inches, respectively, hardly a drop of water would reach the gallery.

The working expense for the Hagari scheme giving a supply of 15 gallons is Rs. 99,000 as given by Mr. Jones; this is no doubt beyond the means of the municipality but for the 10 gallons scheme the working expenses are only 62,000 and it could probably afford that sum—and the supply might, after some years, be increased to 15 gallons which would not be the case as regards other schemes, for I cannot accept the conclusion that the Alipore and Copper Mountain schemes combined would give a supply of 15 gallons per head.

(Signed) D. McNEIL CAMPBELL, Col., R.E.,
President, Sanitary Board.

Proceedings of the Sanitary Board, dated 14th November 1896, No. 247 S.

Read—the following papers:—

G.O., Mis. No. 1010 M., dated 15th June 1896.

Note by the Sanitary Engineer, dated 29th July 1896.
Do. Sanitary Commissioner, No. 334 S.B., dated 10th August 1896.
Do. President, Sanitary Board, No. 153 S., dated 2nd October 1896.
Do. Sanitary Engineer, dated 12th October 1896.
Do. Sanitary Commissioner, No. 443 S.B., dated 22nd October 1896.
Do. President, Sanitary Board, dated 30th October 1896.

Resolution.—The Government of India having in their letter, No. 1342 M.W., dated 16th May 1896, called for a definite scheme for the provision of a pipe water-supply for the town and cantonment of Bellary prior to considering the question of a grant from Imperial funds on account of the cantonment supply, the papers were communicated in G.O., Mis. No. 1010 M., dated 15th June 1896, to the Sanitary Engineer and the Municipal Council, Bellary, for the requisite action.

2. The following four schemes have now been laid before the Sanitary Board:—

(1) The Hagari river scheme.
(2) The Copper Hills scheme.
(3) The Alipore tank scheme.
(4) A combination of (2) and (3).

3. In his notes of the 2nd and 30th October 1896, the President reviews these schemes, and the Board, concurring in his view as to the superiority of the Hagari scheme, resolves to recommend it to Government.

(True Extract.)

(Signed) R. PARSONS,
Secretary, Sanitary Board.

From J. A. JONES, Esq., mem. Inst. c.e., f.r.s.e., Sanitary Engineer to Government, to the Secretary to Government, Local and Municipal Department, dated Fort St. George, 2nd February 1897, No. 207.

In reply to your Memo., No. 93 of 30th January 1897, I have the honour to inform you that there is no irrigation under the Alipore tank. It is a tank belonging to the Military department and used for feeding Fisher's tank and the fort ditch from time to time for the use of the troops.

From H. A. STUART, Esq., Acting Collector of Bellary, to the Secretary to Government, Local and Municipal Department, dated 8th February 1897, Dis. No. 778.

In reply to Government Memo., No. 92 of 30th January 1897, I have the honour to state that the Alipore tank, Bellary taluk, is not used for irrigation purposes, and has no ayacut under it. The tank is used as a resevoir for the water-supply to Bellary town.

2. An estimate for the improvements of this tank at a cost of Rs. 81,900 has been included in the programme of famine-relief works revised up to end of December last. The estimate was prepared by the Sanitary Engineer, Madras, during the famine of 1891–92 and Government in the Public Works Department in its order, No. 1367 W., dated 2nd May 1892, directed the Superintending Engineer, III Circle, to submit a revised estimate with reference to the note by the Chief Engineer for Irrigation printed in the Government Order quoted above. The Superintending Engineer, III Circle, stated in his letter, No. 602, dated 20th May 1892, that the revised estimate called for by Government was submitted by him. The records in this office do not show as to what further action has been taken by Government in the matter. The work has been included in the programme of famine-relief works in accordance with the orders of the Board of Revenue in its Proceedings, Mis. No. 2025, dated 26th February 1892.

ORDER—No. 1463 M., dated 21st June 1897.

The Government is of opinion that the Alipore tank and the Copper Hills schemes for bringing water to the town and cantonment of Bellary must be abandoned owing to the uncertainty of the supply. This leaves for consideration the Hagari scheme, which as recommended by the Sanitary Board in its Proceedings read above, His Excellency in Council is prepared to approve. The Sanitary Engineer estimates the initial cost of this scheme for a supply of 10 gallons per head of the population, which the Government considers should be the minimum quantity for a town like Bellary, at eight lakhs of rupees, exclusive of 1·7 lakhs required for laying down pipes within the cantonment, while the annual charges on account of maintenance and pumping, which will be incurred by the municipal council and the Military department, are put at Rs. 38,000 and Rs. 12,000, respectively. Even with the extended powers of taxation given by the District Municipalities Amendment Act of 1897, the financial resources of the municipal council will not allow of its contributing or borrowing any material proportion of the cost of the construction of the works, and all that it can afford to pay will be its share (Rs. 38,000) of the annual maintenance and pumping charges. As matters stand at present in regard to the Provincial finances, the Government cannot promise any definite grant-in-aid within any definite period. His Excellency in Council communicates this decision to the municipality with much regret. The Government of India will, at the same time, be informed that if the introduction of the water-supply scheme is urgently required in the interests of the military population residing within the cantonment, the whole capital for the construction of the works must be provided from Imperial funds, since there is no other source from which it is possible to find it.

(True Extract.)

G. S. FORBES,
Secretary to Government.

To the Sanitary Board.
„ the Sanitary Commissioner.
„ the Sanitary Engineer.
„ the Collector of Bellary.
„ the Chairman, Municipal Council, Bellary.
„ Public Works Department

Exd. Md Pahilvan.